HANDBOOK OF
OPERATING AND MAINTENANCE INSTRUCTIONS
FOR
TYPE 373 AND TYPE 373A RECTANGULAR COORDINATE RECORDING SYSTEMS

MAY 1953

AIRBORNE INSTRUMENTS LABORATORY, INC.

Mineola, New York

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SAFETY NOTICE

Operating personnel must at all times observe all safety regulations. Do not change tubes or make adjustments inside equipment with the high-voltage supply on. Under certain conditions dangerous potentials may exist in circuits with power controls in the off position because of charges retained by capacitors. To avoid accidents, always remove power, and ground circuits before touching them.

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SECTION I
GENERAL DESCRIPTION

1. GENERAL

The Type 373 (Figure 1-1) and Type 373A (Figure 1-2) Rectangular Coordinate Recording Systems provide, in Cartesian coordinates, inked plots of input voltage as a function of angular position. The units of the Type 373 system include carrying cases and are designed for portable use, whereas the units of the Type 373A system are designed for mounting in a standard 19-inch relay rack. One servo system positions a chart so that the abscissa corresponds to an angular position or to a period of time; a second servo system positions a marking pen so that the ordinate corresponds to a voltage.

The 10-inch ordinate axis on the chart covers an input voltage range of 10,000:1 (80 db). Since the system is supplied for use in measuring antenna radiation patterns, the ordinate axis of the chart is scaled 40 to 0 db to make allowance for the square-law characteristic of the detecting element, which can be a bolometer or crystal. For angular measurements, three scales are provided on the abscissa axis, corresponding to 20.25, 121.5, and 729 inches of paper per 360 degrees. A scale-indicating pen underlines the scale expansion used.

The static error in the pen servo system is $\pm$0.25 db; the dynamic error at the maximum pen speed (40 inches per second) is $\pm$0.4 db. The static error in the chart servo system is $\pm$0.03 inch, which is negligible when compared with the inherent error in the synchros used; the dynamic error at the maximum chart speed (10 inches per second) is $\pm$0.1 inch.

2. DESCRIPTION OF MAJOR UNITS

The Type 373 Rectangular Coordinate Recording System includes:

One Type 373.1 Selective Amplifier
Two Type 373.2 Servo Amplifiers
One Type 373.3 Power Supply
One Type 373.4 Rectangular Coordinate Recorder
One Type 373.5 Interconnecting Cables

The Type 373A Rectangular Coordinate Recording System includes:

One Type 373.12 Selective Amplifier
Two Type 373.22 Servo Amplifiers
One Type 373.32 Power Supply

One Type 373.42 Rectangular Coordinate Recorder
One Type 373.52 Interconnecting Cables

The selective amplifier (Figures 1-3 and 1-4) is a four-stage amplifier in which the frequency for maximum response response is adjustable between 500 and 2000 cps. A current control for a bolometer is also incorporated in this unit.

The servo amplifiers (Figures 1-5 and 1-6) for the pen and chart drives are identical. They are used to supply power to the control field of the two-phase servo motors.

The power supply (Figures 1-7 and 1-8) is a regulated power supply for feeding the recorder and the selective amplifier. This unit also serves as the distribution point of all 115-volt 60-cps power for the servo amplifiers and as a junction box for most of the cabling.

The rectangular coordinate recorder (Figures 1-9 and 1-10) contains the actual chart and its inking pen with all the associated servo motors, gears, and switching assemblies, the logarithmic attenuator, the amplifier, the signal rectifier, and the modulator.

3. REFERENCE DATA

a. Nomenclature: Rectangular Coordinate Recording System

b. No. of packages per complete shipment: six

c. Cubical content: 21 cubic feet

d. Total weight: 400 pounds

e. Frequency range: 500 to 2000 cps

f. Power required for operation: 115 volts, single phase, 60 cps, 450 watts

4. EQUIPMENT SUPPLIED

Type 373 System

Quantity per System	
1	Type 373.1 Selective Amplifier
2	Type 373.2 Servo Amplifiers
1	Type 373.3 Power Supply
1	Type 373.4 Rectangular Coordinate Recorder
1	Type 373.5 Interconnecting Cables

Type 373A System

Quantity per System	
1	Type 373.12 Selective Amplifier
2	Type 373.22 Servo Amplifiers
1	Type 373.32 Power Supply
1	Type 373.42 Rectangular Coordinate Recorder
1	Type 373.52 Interconnecting Cables

5. VACUUM-TUBE COMPLEMENT

UNIT	0A2	5R4-GY	6AL5	6AU6	6C4	6V6	12AU7	12AX7	1620	5651	6L6	6AS7
Selective Amplifier						2	1		2			
Servo Amplifier (A)	1	1			1		1				2	
Servo Amplifier (B)	1	1			1		1				2	
Power Supply	1	1						1		1		1
Recorder			2	1			2		1			

FIGURE 1-1. TYPE 373 RECTANGULAR COORDINATE RECORDING SYSTEM

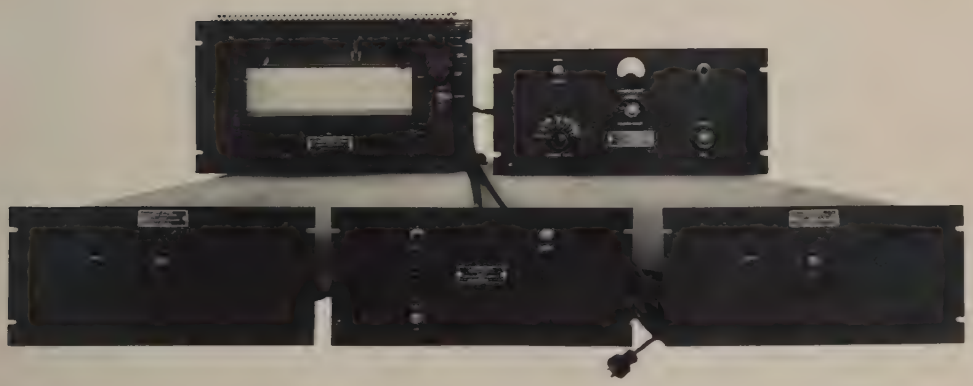

FIGURE 1-2. TYPE 373A RECTANGULAR COORDINATE RECORDING SYSTEM

FIGURE 1-3. TYPE 373.1 SELECTIVE AMPLIFIER

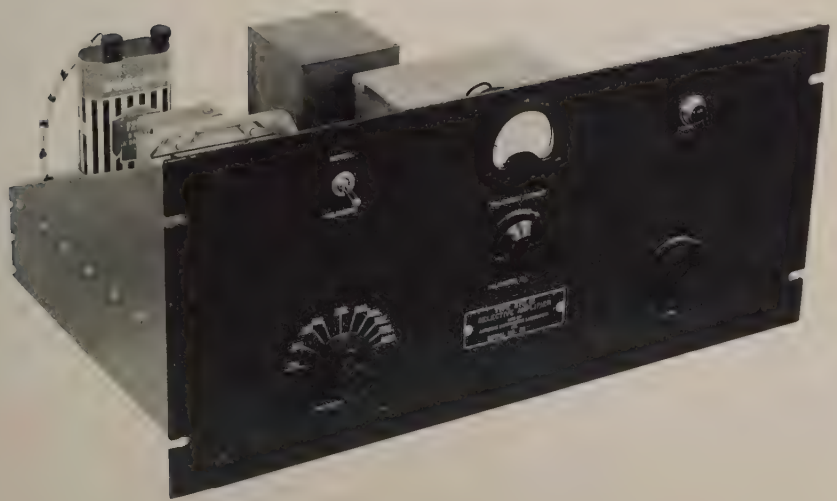

FIGURE 1-4. TYPE 373.12 SELECTIVE AMPLIFIER

FIGURE 1-5. TYPE 373.2 SERVO AMPLIFIER

FIGURE 1-6. TYPE 373.22 SERVO AMPLIFIER

FIGURE 1-7. TYPE 373.3 POWER SUPPLY

FIGURE 1-8. TYPE 373.32 POWER SUPPLY

FIGURE 1-9. TYPE 373.4 RECTANGULAR COORDINATE RECORDER

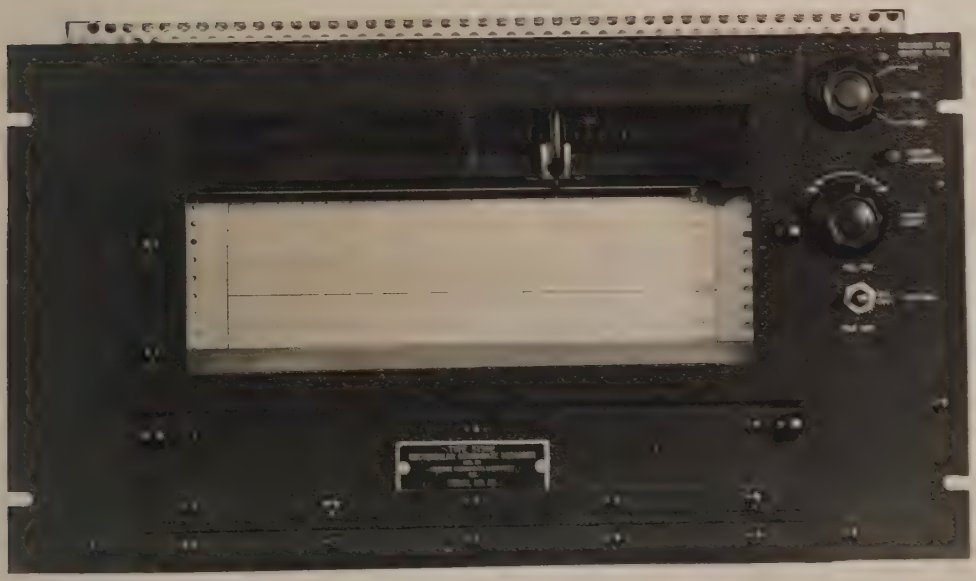

FIGURE 1-10. TYPE 373.42 RECTANGULAR COORDINATE RECORDER

SECTION 2
THEORY OF OPERATION

1. GENERAL

The rectangular coordinate recording system (Figure 2-1) is used to plot the logarithm of the input voltage from any 200-ohm a-c source having a frequency between 500 and 2000 cps against angular data. The system is especially suitable for plotting the field-strength patterns of narrow-beam antennas. In this application, the field-strength signal is obtained with a bolometer or crystal (not supplied), and this signal is used to position the inking pen. The angular position is obtained from the two synchro-generators of a 1:1 and 36:1 data transmission system. The signal from either of the two synchros is used to position the chart. The angular heading and the relative signal strength are two independent servo systems: the pen-positioning system and the chart-positioning system. Although the following descriptions are given for the particular case of recording antenna radiation patterns, the recording system can be used to plot any voltage variation as a function of angular position--provided that the following conditions are met:

a. The frequency of the input signal is between 500 and 2000 cps.

b. The amplitude of the input is not less than 2.0 microvolts.

2. PEN-POSITIONING SYSTEM

The pen-positioning system as set up to measure antenna patterns is shown in Figure 2-2. The r-f signal is detected by a bolometer or crystal, and the resulting audio signal is fed into the selective amplifier, where the signal is amplified and the harmonics and noise are selectively attenuated. The power stage of this amplifier feeds the logarithmic attenuator. The contact on the pen carriage picks off an attenuated signal from the attenuator. This attenuated signal is amplified, rectified, and then compared with a fixed d-c reference. The difference between the rectified signal and the reference voltage is fed into a balanced modulator. The output of the modulator is a 60-cps signal that is proportional to the difference voltage and either in phase with a 60-cps reference voltage or 180 degrees out of phase--depending upon whether the rectified signal is greater or smaller than the reference voltage. This difference or error voltage is

fed into a servo amplifier, which amplifies the signal and supplies power to the control field of the pen drive motor. The fixed field of this motor is supplied by a voltage that is shifted 90 degrees from the 60-cps reference voltage by a series capacitor. The power supplied to the control field is of the proper phase to cause the motor to turn in a direction that moves the pen along the attenuator until the rectified signal is equal to the reference voltage. Because the attenuator has an exponential voltage decay along its length, the distance along the attenuator to the balance point is a measure of the logarithm of the input signal. An induction generator, which has an output voltage proportional to its velocity, is mechanically coupled to the pen motor. This voltage provides a damping signal to the servo amplifier to prevent hunting or large overshoots when recording rapidly changing signals.

a. SELECTIVE AMPLIFIER

The selective amplifier (Figure 2-3) is a four-stage band-pass unit, the input stage of which has a parallel-T feedback network. This network is a band-rejection filter that feeds back signals of all frequencies except the band to which it is tuned. Thus it tends to cancel all signals and noise outside the band to which it is tuned. The bandwidth has been set at 35 cps, which is the minimum consistent with the desired response of the pen servo system. The signal from the tuned stage is further amplified and used to drive a pair of 6V6's in push-pull through a phase inverter. The 6V6 output stage feeds the 340-ohm logarithmic attenuator, which is housed in the recorder unit. Plate and filament voltages for the amplifiers are supplied by the power supply.

b. LOGARITHMIC ATTENUATOR

The logarithmic attenuator (Figure 2-4) consists of a continuously wound resistance element with taps to form 21 "T" sections. The voltage along this attenuator closely approximates an exponentially falling curve as a function of the distance from the input end. The maximum voltage attenuation is 10,000:1.

c. RECTANGULAR COORDINATE RECORDER

Figure 2-5 is a schematic diagram of the rectangular coordinate recorder, and Figure 2-6 is a simplified schematic diagram of the amplifier, signal rectifier, and modulator sections of this unit. The signal that is taken from the logarithmic attenuator is amplified through a two-stage amplifier. To reduce microphonic effects, the first stage is shock-mounted. The amplified signal is rectified, filtered, and compared with a fixed d-c reference,

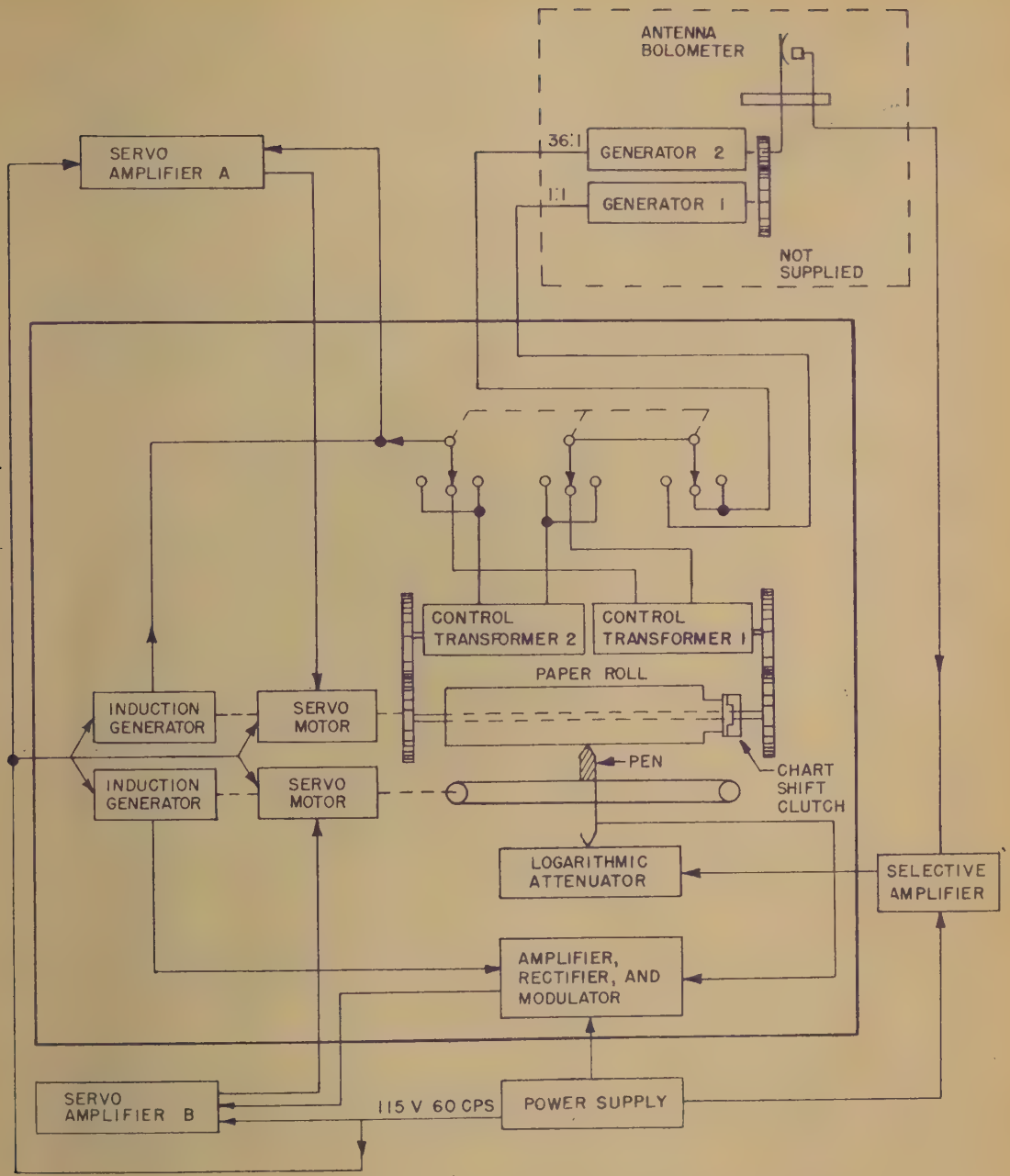

FIGURE 2-1. BLOCK DIAGRAM OF RECTANGULAR COORDINATE RECORDING SYSTEM

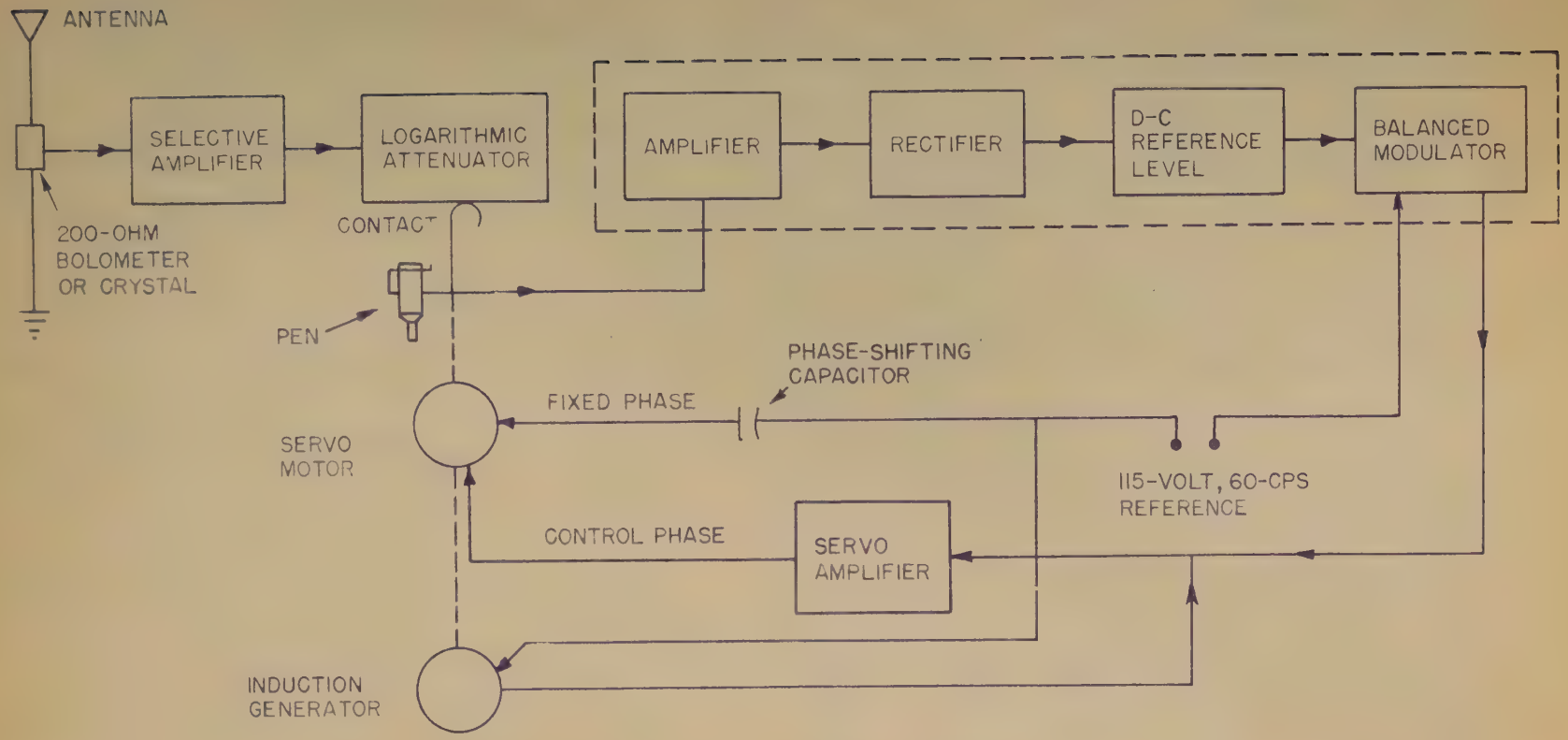

FIGURE 2-2. BLOCK DIAGRAM OF PEN-POSITIONING SYSTEM

and the difference signal is fed into one side of the balanced modulator (V406A and V405B); the other side (V406B and V405A) is grounded. The cathodes of the modulator tubes (V405 and V406) are fed with the 60-cps reference voltage. When the grids of V406A and V405B are at ground potential, the tubes are all operating in the same region and have the same transconductance; because the cathodes are driven in opposite phase by the 60-cps reference voltage, the resultant plate currents balance and there is no 60-cps output across T401. When a voltage is applied to the grids of V406A and V405B, these tubes operate with a different transconductance than V406B and V405A. Thus the plate currents are no longer balanced, and a 60-cps voltage appears across T401. This 60-cps signal is either in phase or 180 degrees out of phase with the reference voltage, depending upon the polarity of the voltage applied to the grids of V406A and V405B.

The signal picked off the attenuator is always at the same level when the error is reduced to zero. Therefore, the amplifier, rectifier, and modulator always operate at the same level, with the result that the linearity of these units does not affect the accuracy of the recorder.

For large error signals, the damping constant of the servo system changes because of the nonlinear effect of the logarithmic attenuator. The clipping circuit after the amplifier is used to keep the damping constant above an adjustable minimum.

d. SERVO AMPLIFIER

The servo amplifier (Figure 2-7) consists of a three-stage voltage amplifier, and a transformer-coupled push-pull power output stage. The output stage supplies power to the control field of the two-phase servo motor. This unit contains its own power supply.

3. CHART-POSITIONING SYSTEM

The chart-positioning system is shown in Figure 2-8. In a particular application, such as plotting the field-strength pattern of an antenna, a synchro-generator is mechanically attached to the antenna mount, and this transmits the antenna heading electrically to the synchro control transformer in the recorder. The output of the control transformer is a 60-cps signal that, for small error angles, has a magnitude proportional to the error between its rotor and the relative antenna heading. This 60-cps signal is either in phase or 180 degrees out of phase with the 60-cps reference voltage, depending upon whether the control-transformer rotor is lagging or leading the antenna mount. This signal or error voltage is amplified by the servo amplifier, which supplies power to the control field of the servo motor. The servo motor drives

the control transformer until this error is reduced to zero. Thus the paper roll, which is mechanically geared to the control-transformer rotor, is kept in alignment with with the antenna. The induction generator, which is tied mechanically to the servo motor, provides a damping signal.

Terminals are provided for connections to a single- or dual-speed synchro system in the antenna mount--that is, a 1-speed and a 36-speed generator on the antenna mount. In conjunction with two control transformers and appropriate switching in the recorder (Figure 2-5), this permits the use of three scale expansions for the chart drive: 20.25, 121.5, and 729 inches of paper per revolution of the antenna. The paper is kept under constant tension when moving in either direction by a small bearing-mounted two-phase induction motor. The damping signal is provided by a drag-cup induction generator.

The synchro-generators are not supplied with the system, but should be Size 5, 115 volts, 60 cps. The servo amplifier is described in paragraph 2d of this section.

4. POWER SUPPLY

The power supply (Figure 2-9) furnishes the plate supply voltages for the recorder unit; it also supplies the plate voltage and filament power for the selective amplifier.

It has a conventional full-wave rectifier circuit with two stages of L-C filtering and an electronic voltage regulator to supply +250 volts at 150 ma. This is used to supply plate voltage for the selective amplifier and the recorder. A gas tube is used as the regulator for the 150 volts at 10 ma. The +150 volts is used as a screen supply and an additional plate supply in the recorder. The filament supply is 3 amperes at 6.3 volts, 60 cps; this supplies filament power to the selective amplifier.

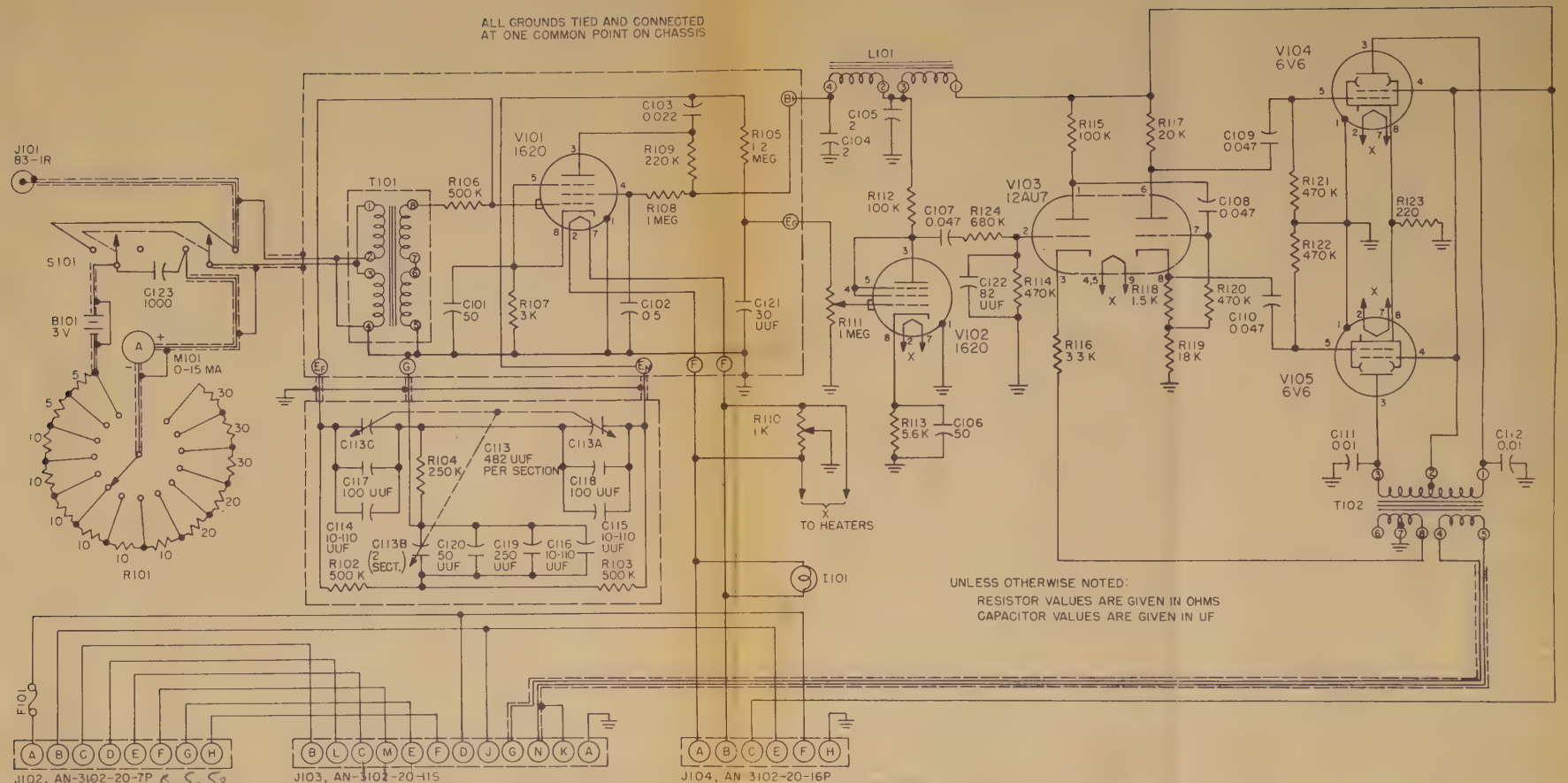

FIGURE 2 3 SCHEMATIC DIAGRAM OF SELECTIVE AMPLIFIER

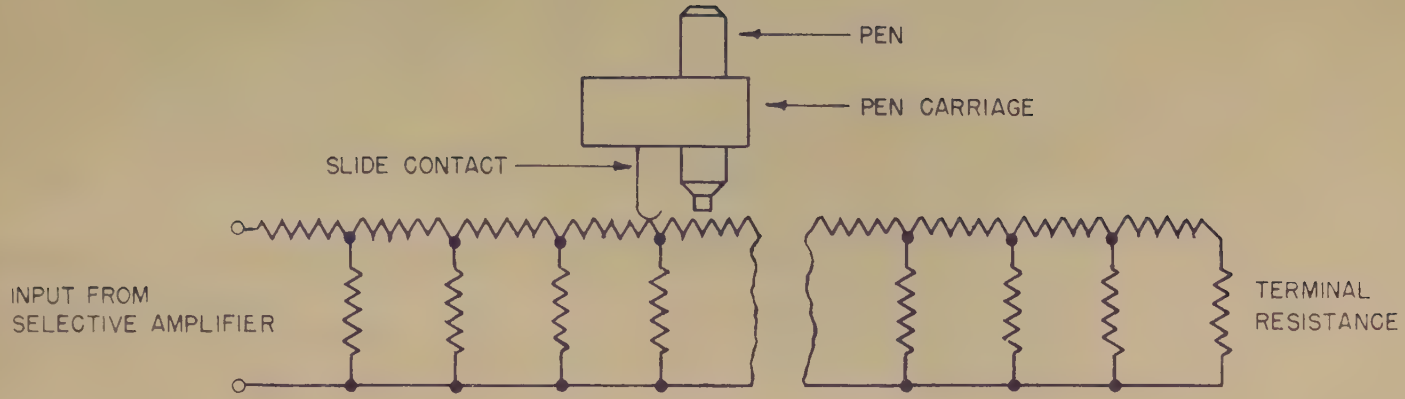

FIGURE 2-4. SCHEMATIC DIAGRAM OF LOGARITHMIC ATTENUATOR

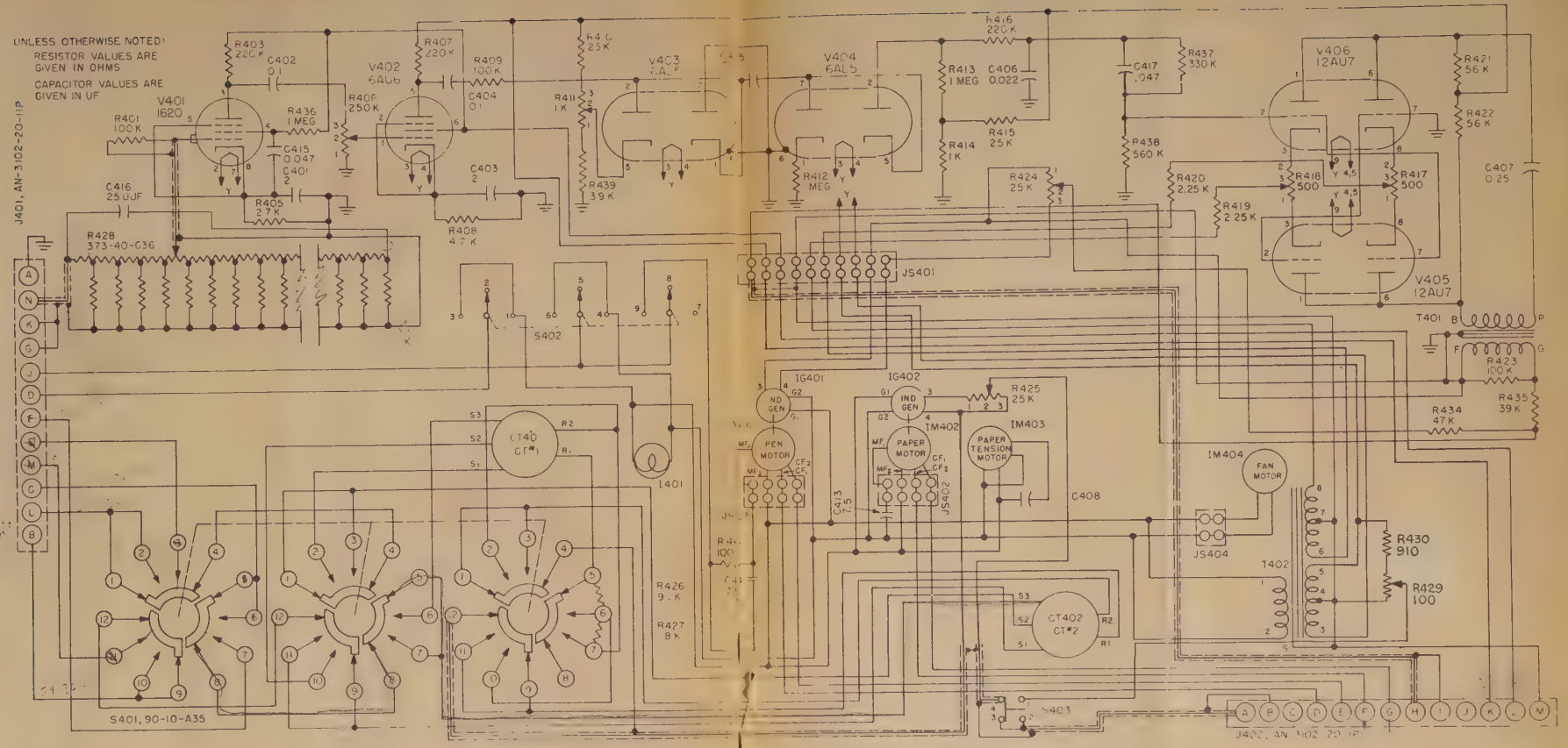

FIGURE 2-5 SCHEMATIC DIAGRAM OF RECTANGULAR COORDINATE RECORDER

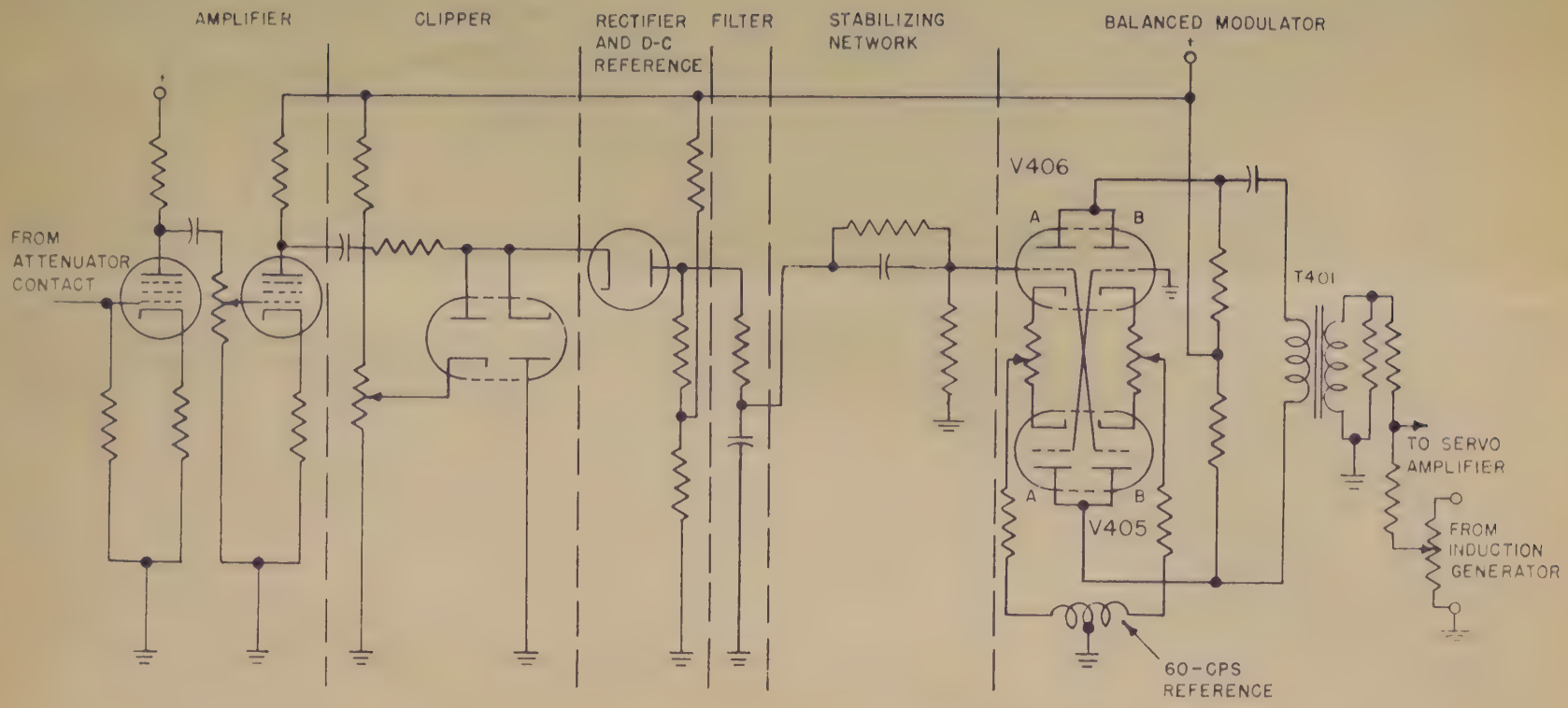

FIGURE 2-6 SIMPLIFIED SCHEMATIC DIAGRAM OF AMPLIFIER, SIGNAL RECTIFIER, AND MODULATOR

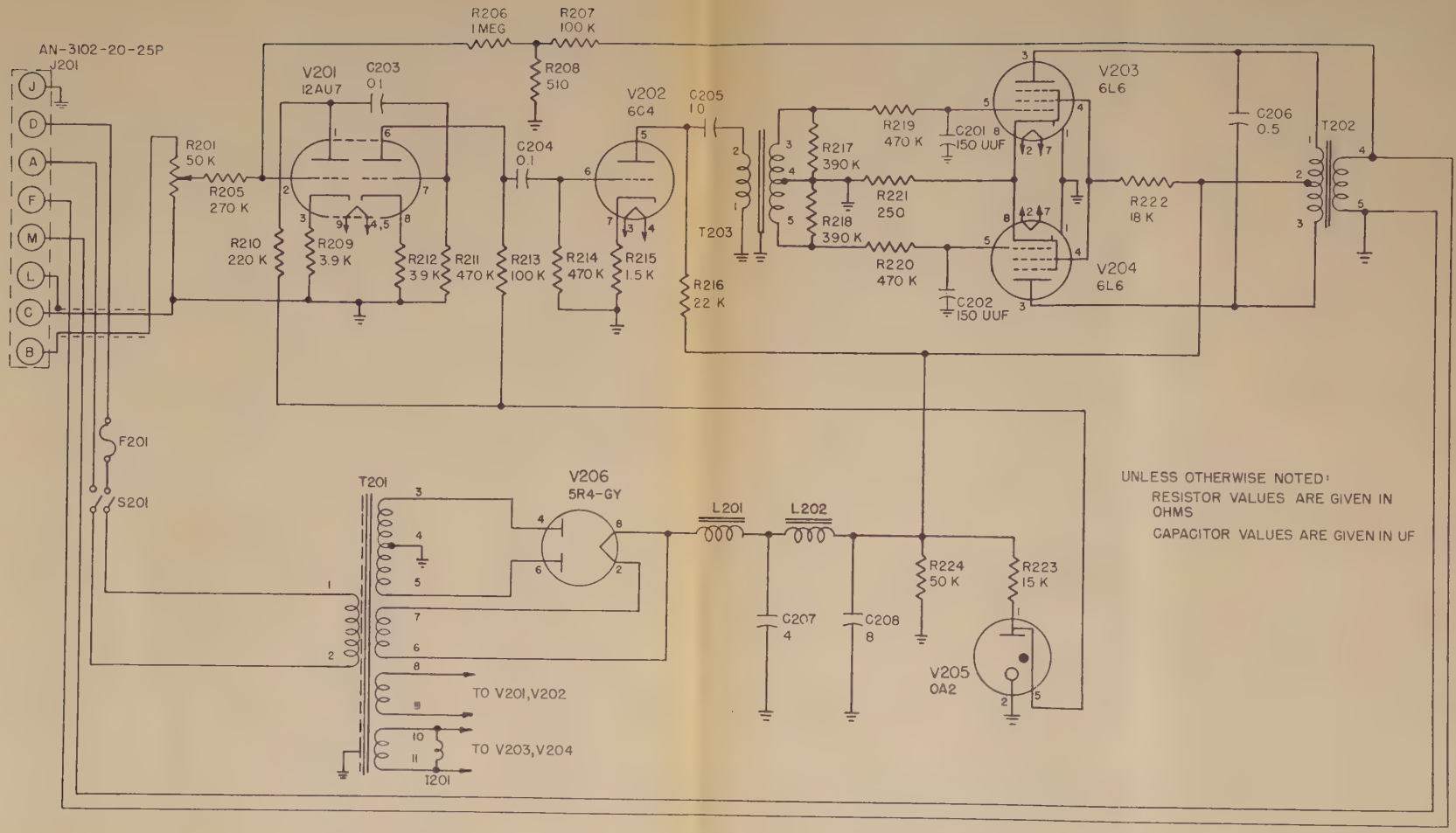

FIGURE 2-7 SCHEMATIC DIAGRAM OF SERVO AMPLIFIER

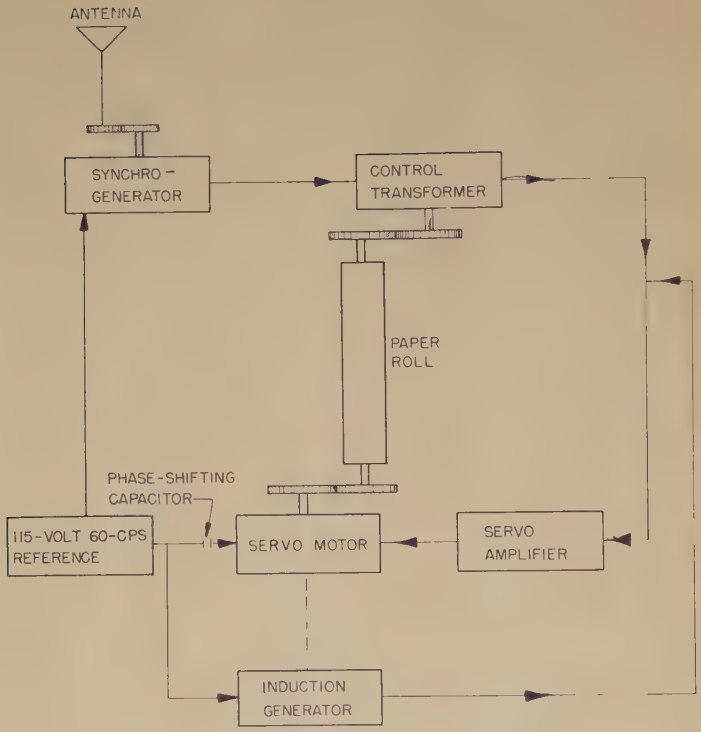

FIGURE 2-8 BLOCK DIAGRAM OF CHART-POSITIONING SYSTEM

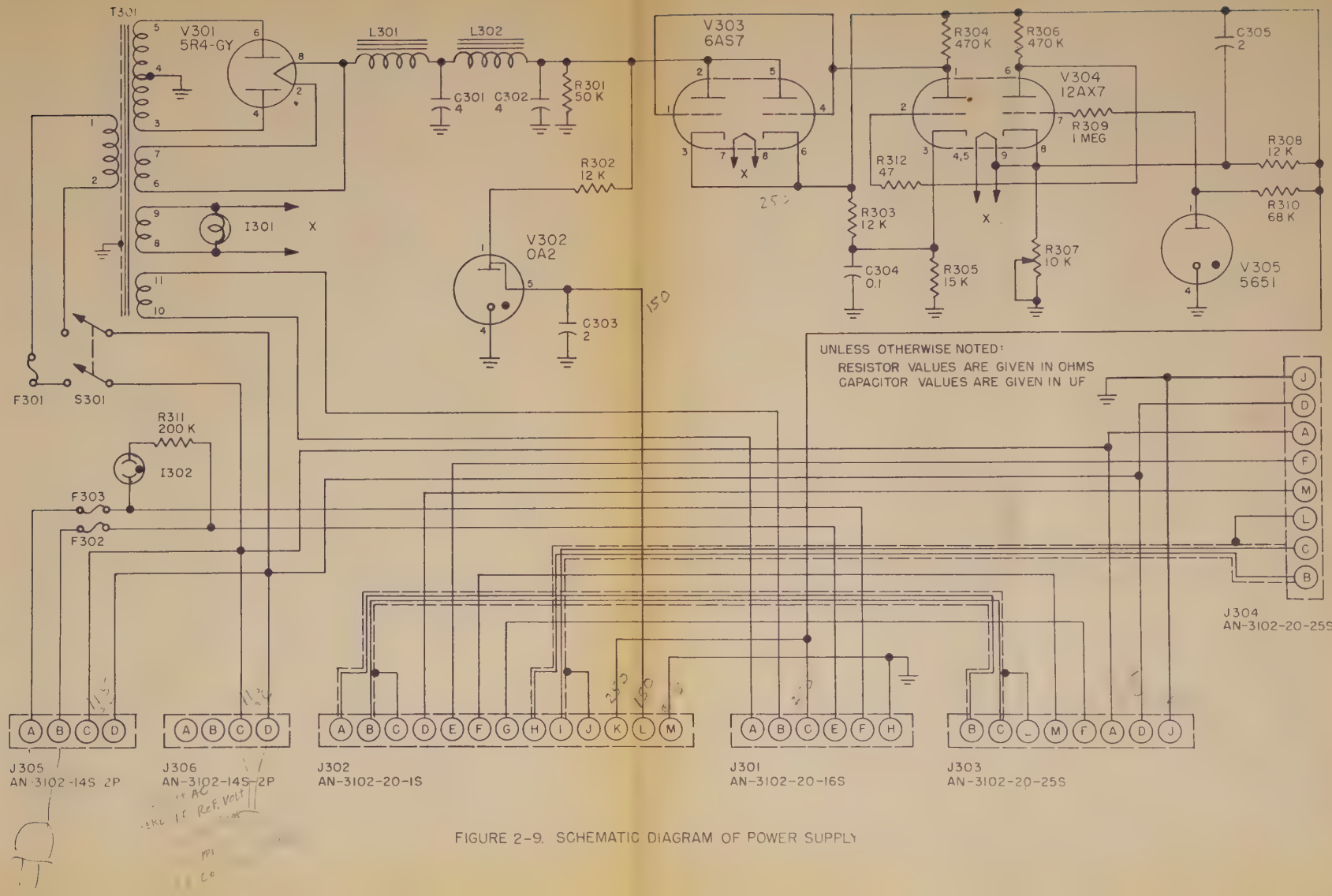

FIGURE 2-9. SCHEMATIC DIAGRAM OF POWER SUPPLY

SECTION 3
INSTALLATION

1. GENERAL

The equipment is ready for use when shipped, and there should be no need for any servicing or adjustment before operating. However, the equipment should be inspected for any damage that might have occurred during shipment.

2. INSTALLATION

a. TYPE 373 SYSTEM

All the units of the Type 373 system must be operated outside their carrying cases except for the recorder, which can be operated either in its case or mounted on a rack. Case operation is recommended in order to exclude dirt from the recorder mechanism.

b. TYPE 373A SYSTEM

All the units of the Type 373A system can be operated on the bench or mounted in a standard 19-inch relay rack. If the relay rack has a closed cabinet, a blower should be installed to dissipate the heat developed by the units. For convenience, the recorder and the selective amplifier should be mounted above the power supply with the two servo amplifiers below. A blank strip is furnished to fill the panel space above the recorder.

3. INTERCONNECTION OF UNITS

With the exception of P305-6, connect the units as shown in Figure 3-1. If the pilot lamp in the power supply marked REFERENCE VOLTAGE is lit, it means that reference voltage is being supplied to the synchro-generators in the unit under test and to the recorder unit; P305-6 should then be connected to J306, where it will supply power only to the power supply and servo amplifiers.

If the REFERENCE VOLTAGE lamp is not lit, then P305-6 should be connected to J305, where it will supply power not only to the power supply and servo amplifiers, but also will supply power and a reference voltage to the recorder unit and to the synchro-generators. When P305-6 is connected into J305, the REFERENCE VOLTAGE lamp will light because reference voltage is not being supplied through P305-6.

The connections for P102 (AN3106-20-7S) are as follows:

Pin No.	Synchro Connection	
A	R_1	115 v, 60 cps
B	R_2	
C	S_1	
D	S_2	36:1
E	S_3	
F	S_1	
G	S_2	1:1
H	S_3	

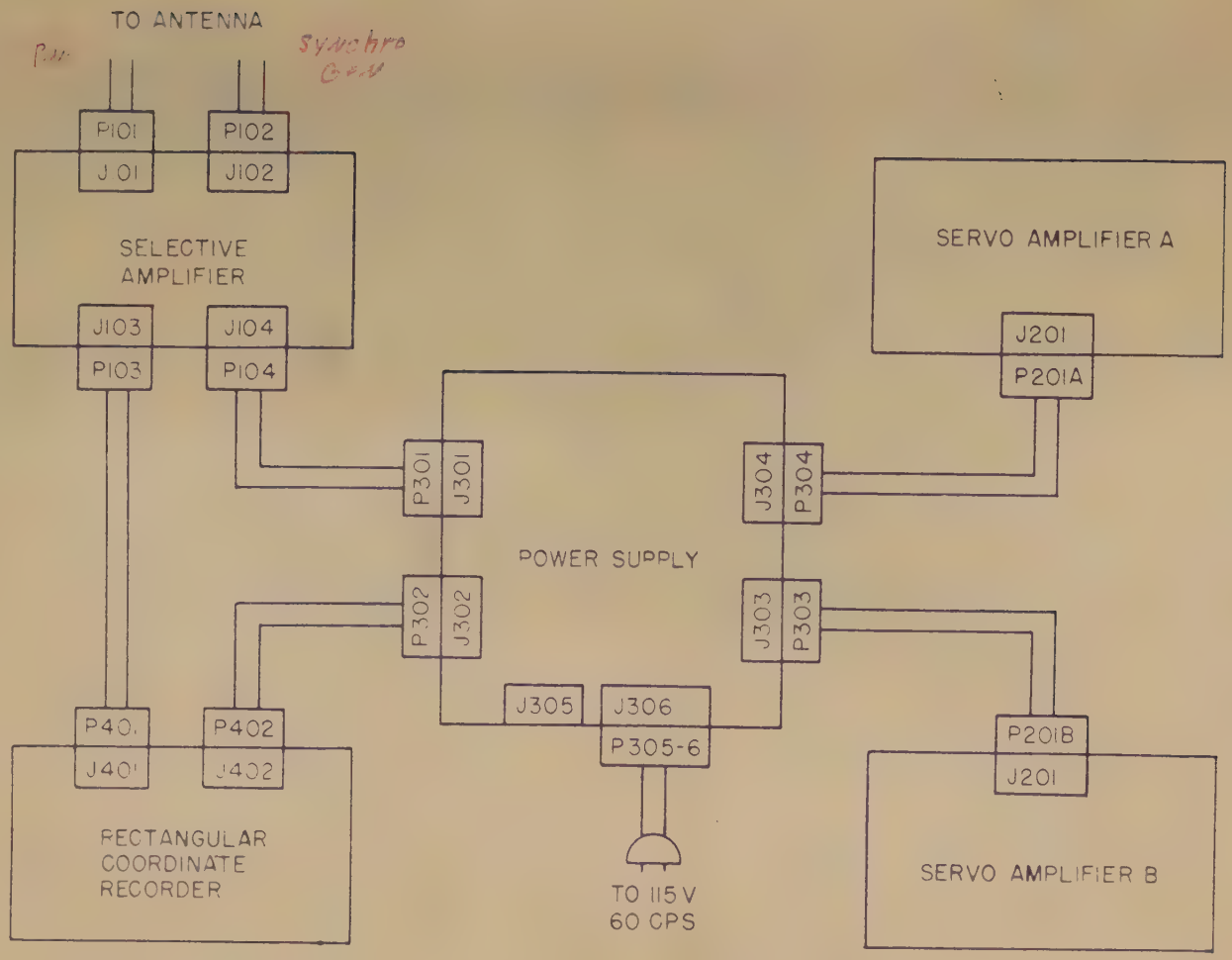

FIGURE 3-1 INTERCONNECTING CABLES

SECTION 4
OPERATION AND ADJUSTMENT

1. OPERATION

Before operating the rectangular coordinate recording system, make sure that the input signal frequency is between 500 and 2000 cps. To operate the equipment proceed as follows.

Before connecting the units, set all the power switches in the OFF or ALL OFF position, and set the tuning control on the selective amplifier to the approximate frequency of the input signal.

Although both servo amplifiers are interchangeable electrically, each unit has been adjusted for optimum performance in its particular system--that is, the servo amplifier with a serial number ending in "A" has been adjusted for the pen-positioning system, and the servo amplifier with a serial number ending in "B" has been adjusted for the chart-positioning system. Interchanging the two amplifiers requires readjusting the gain controls as described in paragraph 3 of this section.

Connect the units as shown in Figure 3-1, taking the precaution of connecting P305-6 in the manner described in paragraph 3 of Section 3.

Next, connect the bolometer or crystal to the selective amplifier, and throw the BOLOMETER-CRYSTAL switch to the proper position. When the switch is in the BOLOMETER position, the self-contained battery, the current control, and the milliammeter are put in series with the input to the amplifier so as to supply the necessary bolometer current. Before making the connection, place the BOLOMETER CURRENT control in the maximum counterclockwise position (to avoid damaging the meter and bolometer), and then adjust it for the desired current after the connection has been made. When the BOLOMETER-CRYSTAL switch is in the CRYSTAL position, input receptacle J101 is connected directly to the input of the amplifier.

Put the paper in the recorder as follows, referring to Figures 4-1, 4-2, and 4-3.

a. Open the top door.

b. Remove the plotting pen.

c. Lift the scale-indicating pen holder to the upper position.

d. Lift the pressure roller to the upper position.

e. Open the lower door.

f. Push the end caps of the paper roll into the paper roll, and place the paper roll in the recorder as shown in Figure 4-3.

g. Roll out about 10 inches of paper, and cut the end as shown in Figure 4-2 to facilitate feeding of paper.

h. Slide the paper in between the guide plates until it appears at the top of the platen roller.

i. Pull the end of the paper through until the holes in the paper engage the platen roller pins.

j. Turn the CHART SHIFT control in the DN direction (counterclockwise), and at the same time slowly pull the paper until about 12 inches of paper extends from the platen roller.

k. Close the bottom door.

l. Slide the paper between the drive roller and the pressure roller.

m. Lower the pressure roller against the drive roller.

n. Lower the scale-indicating pen holder.

o. Close the top door, leaving the paper extending through the slot between the two doors.

Now turn the toggle switch on the recorder to the PEN OFF position, and roll out at least 11 inches of paper with the CHART SHIFT control. This prevents the possibility of the chart rolling up inside the recorder when the chart servo aligns the chart with the generators in the antenna mount.

Next turn on the power supply and both servo amplifiers; throw the switch on the recorder to the ALL ON position. With the unit to be measured approximately in the angular position that corresponds to the maximum signal input, set the gain on the selective amplifier at maximum, and tune the amplifier with the frequency control until the pen carriage has a maximum deflection to the left. If the carriage goes into the stops at the left, decrease the gain enough to bring it away from the stops, and retune for maximum deflection. To protect the carriage, cable, etc., from damage when it goes into the stops, the carriage is connected to the servo motor through a friction clutch.

If the CHART SHIFT control is pushed in while switching scales, excessive strains on the chart will be avoided.

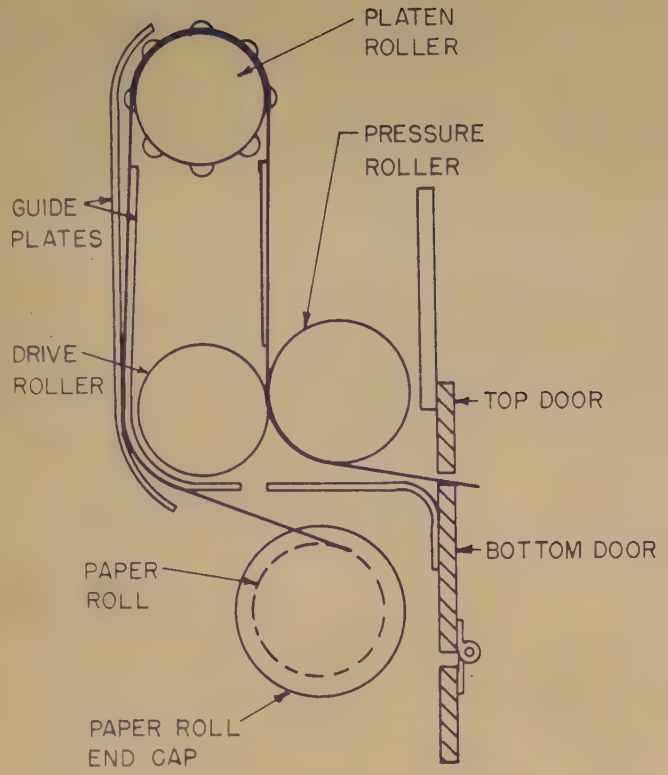

FIGURE 4-1. PAPER FEED SYSTEM

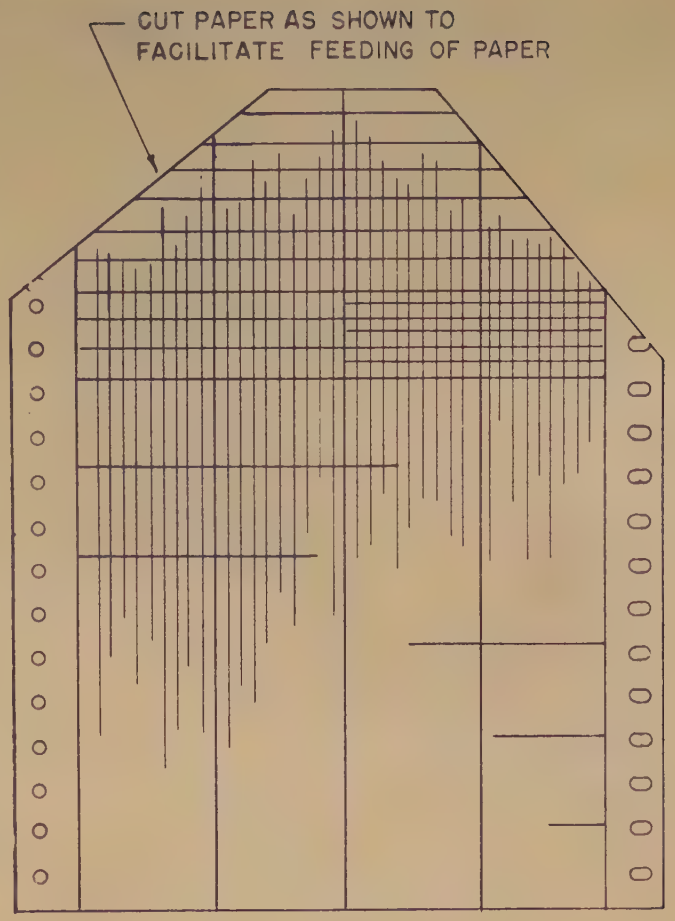

FIGURE 4-2. PLOTTING PAPER

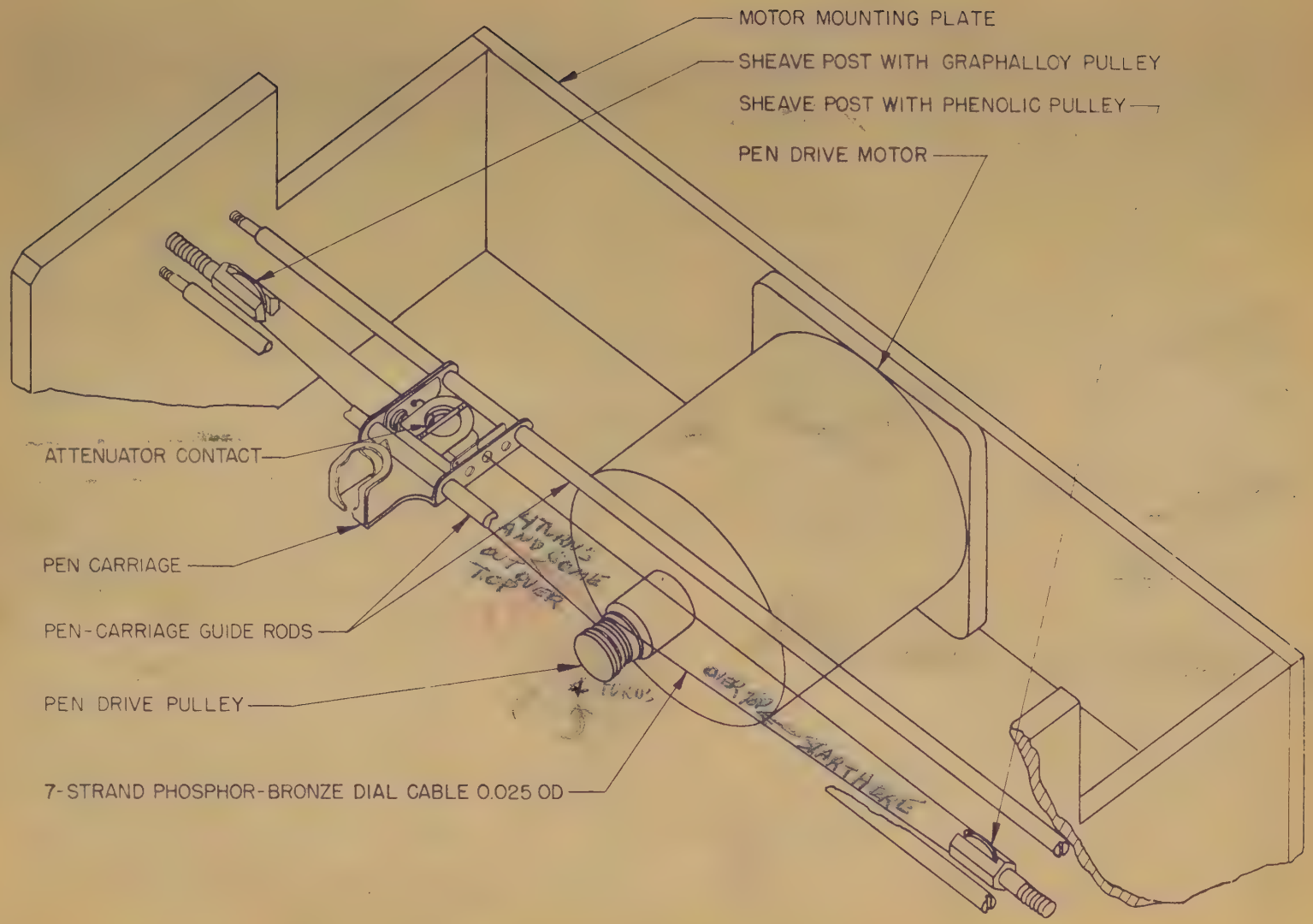

FIGURE 4-4. PEN CABLE ASSEMBLY

With the CHART SHIFT control pushed in, set the scale expansion switch to the desired scale expansion--10, 60, or 360 degrees per chart cycle (20.25 inches).

Now rotate the unit under test through the desired angle, and stop it at the point of maximum deflection of the pen carriage to the left. At this angle, adjust the GAIN control on the selective amplifier so that the carriage pointer reads 0 db or as close to it as possible, depending upon the received signal strength.

Rotate the unit to the initial position of the angular arc to be covered, and place the pen in the carriage. Now the unit can be rotated through the desired angle, and the signal strength will be plotted automatically. After the plot has been made, roll out the paper until the edge of the pattern is outside the recorder, and tear off the pattern.

If it is desired to advance the chart one chart cycle (20.25 inches), press the CHART ADVANCE button, and release it. The chart will roll out about 20 inches, the button will reset itself, and the system will re-zero one chart cycle from its original position.

2. MAINTENANCE

Any units that give trouble should be serviced in accordance with the standard procedures for maintenance of electronic equipment. Voltage-checking charts (Tables 4-1, 4-2, 4-3, and 4-4) are provided to simplify servicing. Occasionally it will be necessary to replace the pen-carriage cable and the bolometer battery.

a. PEN-CARRIAGE CABLE

To replace the pen-carriage cable, remove the attenuator shield, attenuator, recorder chassis, and motor mounting plate with the pen drive motor (Figure 4-4). Loosen the two sheave posts, and wind a 3-1/2 foot piece of cable four times around the pen drive pulley, making sure that the cable is wound in the direction shown in Figure 4-4. Feed one end of the cable around the graphalloy pulley and the other end around the phenolic pulley. Attach the motor mounting plate, and at the same time keep a tension on both ends of the dial cable to avoid any possibility of tangling the cable. Take one end of the dial cable and feed it through the corresponding side of the pen carriage; tie a knot in this end, and put a drop of solder on the knot. Repeat this procedure with the other end, leaving enough slack in the cable so that when the sheave posts are tightened up, the cable will be under a slight tension. Tighten the sheave post with the graphalloy pulley securely, and bring the other sheave post up to within about 1/16 inch of the end plate. Solder the flexible lead from the

attenuator contact to the end of the cable that is nearest the graphalloy pulley. Replace the attenuator, and lower it until the attenuator contact is in a horizontal position at both ends of the carriage travel. Now replace the remaining parts.

b. BOLOMETER BATTERY

To replace the battery that supplies the bolometer current, remove the dust cover from the selective amplifier. The positive terminal is red.

3. ADJUSTMENT

Before making any adjustment, first determine whether the trouble lies in the pen-positioning system or in the chart-positioning system by shutting off one servo amplifier at a time. Then follow the adjustment procedure for the particular system, remembering that the servo amplifier with the serial number ending in "A" has been adjusted for the pen-positioning system and the one with the serial number ending in "B" has been adjusted for the chart-positioning system.

a. PEN-POSITIONING SYSTEM

This procedure is best followed with the pen removed and the chart servo amplifier turned off. The recorder unit will have to be removed from its case in order to expose the various controls. An audio oscillator, a cathode-ray oscilloscope, and a vacuum-tube voltmeter are necessary for adjusting the pen servo.

Turn the power supply on and the recorder power switch to the ALL ON position. With the pen servo amplifier turned off, balance the modulator by adjusting R417 and R418 (Figure 4-5) for minimum 60-cps voltage between terminal G of T401 and ground, with pin 2 of V406 shorted to ground. Lock R417 and R418 at this time. Now, with a 2.0 millivolt audio signal (between 500 and 2000 cps) from the grid of V401 to ground and R411 (Figure 4-5) turned to its maximum clockwise position, adjust R406 for a minimum 60-cps voltage from terminal G of T401 to ground and lock R406.

Turn the pen servo amplifier on, and feed an audio signal of about 1 volt across the input terminals of R428 (Figure 4-6). Set R424 (Figure 4-7) at its maximum clockwise position. With the servo amplifier gain control (R201) in its maximum clockwise position and locked, proceed as follows:

(1) Place the plotting pen in the pen carriage.

(2) Turn the toggle switch on the recorder (S402) to the PEN ORF position.

(3) Displace the pen to the left about 2.5 inches.

(4) Quickly turn the switch to the ALL ON position.

(5) Notice the amount of overshoot, if any.

(6) Turn R424 on the RECORDER CHASSIS ~~servo amplifier~~ counterclockwise in small increments, and repeat steps (2) to (6) until the overshoot is about 1/8 inch.

(7) Lock R424.

(8) If the pen has a slight jiggle or high-frequency oscillation, turn R201 slightly counterclockwise and repeat steps (1) through (7).

Adjust R411 at this time by turning it counterclockwise in small increments until the overshoot is the same when the pen is displaced to the right as it is when the pen is displaced to the left. Lock R411. This adjustment will probably shift the rest position of the pen to the right.

Adjust the selective amplifier for minimum noise level by unscrewing the dust cover on the battery side and adjusting R110 (Figure 4-8) for minimum voltage across the input terminals of R428 with the input receptacle (J101) shorted and the GAIN control set at maximum gain. Lock R110 and fasten the dust cover.

Feed about 5 millivolts of audio signal into the input receptacle (J101) of the selective amplifier. Tune the amplifier for maximum deflection to the left. If the amplifier is working properly, the pen can be moved from the stops on the left into the stops on the right by turning the GAIN control throughout its range.

b. CHART-POSITIONING SYSTEM

Turn the pen servo amplifier off. Set the GAIN control (R201) on the chart servo amplifier at its maximum counterclockwise position; set R425 in the recorder (Figure 4-5) at its maximum counterclockwise position. Turn R201 slowly clockwise until the system oscillates at a low frequency when the platen roller is given a push in either direction. Then turn R425 slowly clockwise until the oscillation stops. Repeat in small increments until the point is reached where further turning of R425 causes the system to go from a low-frequency oscillation to a high-frequency oscillation without passing through a region of no oscillation. At this point, turn R201 back about 10 degrees, and readjust R425 so that it is about halfway between the positions that result in low- and in high-frequency oscillation. Lock R201 on the chart servo amplifier and R425 on the recorder.

c. AUTOMATIC CHART ADVANCE

The automatic chart advance should be adjusted only after it is known that the chart-positioning system is working properly.

Turn R429 to its maximum clockwise position. Push the CHART ADVANCE button and slowly turn R429 (Figure 4-5) counterclockwise until one chart cycle (20.25 inches) of paper reels out in about 5 seconds and lock R429.

TABLE 4-1

VOLTAGE-CHECKING TABLE FOR

SELECTIVE AMPLIFIER

	PIN NUMBER							
TUBE	1	2	3	4	5	6	7	8
V101			100	65	2.5	240		2.5
V102			135	135	135	240		5.7
V103	100		5.0			180	52	69
V104			245	250				13.5
V105			245	250		64		13.5

All voltages dc with respect to ground, and measured with a vacuum-tube voltmeter.

Voltage readings taken with input grounded at J101, and GAIN control set at maximum.

Equivalent input noise voltage $\approx$ 3 x 10^{-8} volt (maximum gain and 200 ohms across J101).

Maximum input voltage (without saturation) $\approx$ 10 millivolts.

TABLE 4-2
VOLTAGE-CHECKING TABLE FOR
SERVO AMPLIFIER

	PIN NUMBER							
TUBE	1	2	3	4	5	6	7	8
V201	30		1.7			53		3.3
V202	210				210		10	
V203			360	270				24
V204			360	270				24
V205	150				150			
V206		420						420

All voltages dc with respect to ground, and measured with a vacuum-tube voltmeter. Readings taken with input grounded.

TABLE 4-3
VOLTAGE-CHECKING TABLE FOR
POWER SUPPLY

	PIN NUMBER								
TUBE	1	2	3	4	5	6	7	8	9
V301		465						465	
V302	150				150				
V303	140	440	250	140	440	250	87	87	
V304	140	135	135	87	87	135	79	87	87
V305	87				87				

All voltages dc with respect to ground, and measured with a vacuum-tube voltmeter. Readings taken under no-load condition.

TABLE 4-4

VOLTAGE-CHECKING TABLE FOR

RECTANGULAR COORDINATE RECORDER

	PIN NUMBER							
TUBE	1	2	3	4	5	6	7	8
V401			58	36	1.3	150		1.3
V402		4.5			100	150	4.5	
V403	0.70	0.70			40			
V404	4.0	3.4			3.7		3.7	
V405	105		6.0			105	1.7	6.0
V406	105	1.7	6.0			105		6.0

All voltages dc with respect to ground, and measured with a vacuum-tube voltmeter. Readings taken with input grounded.

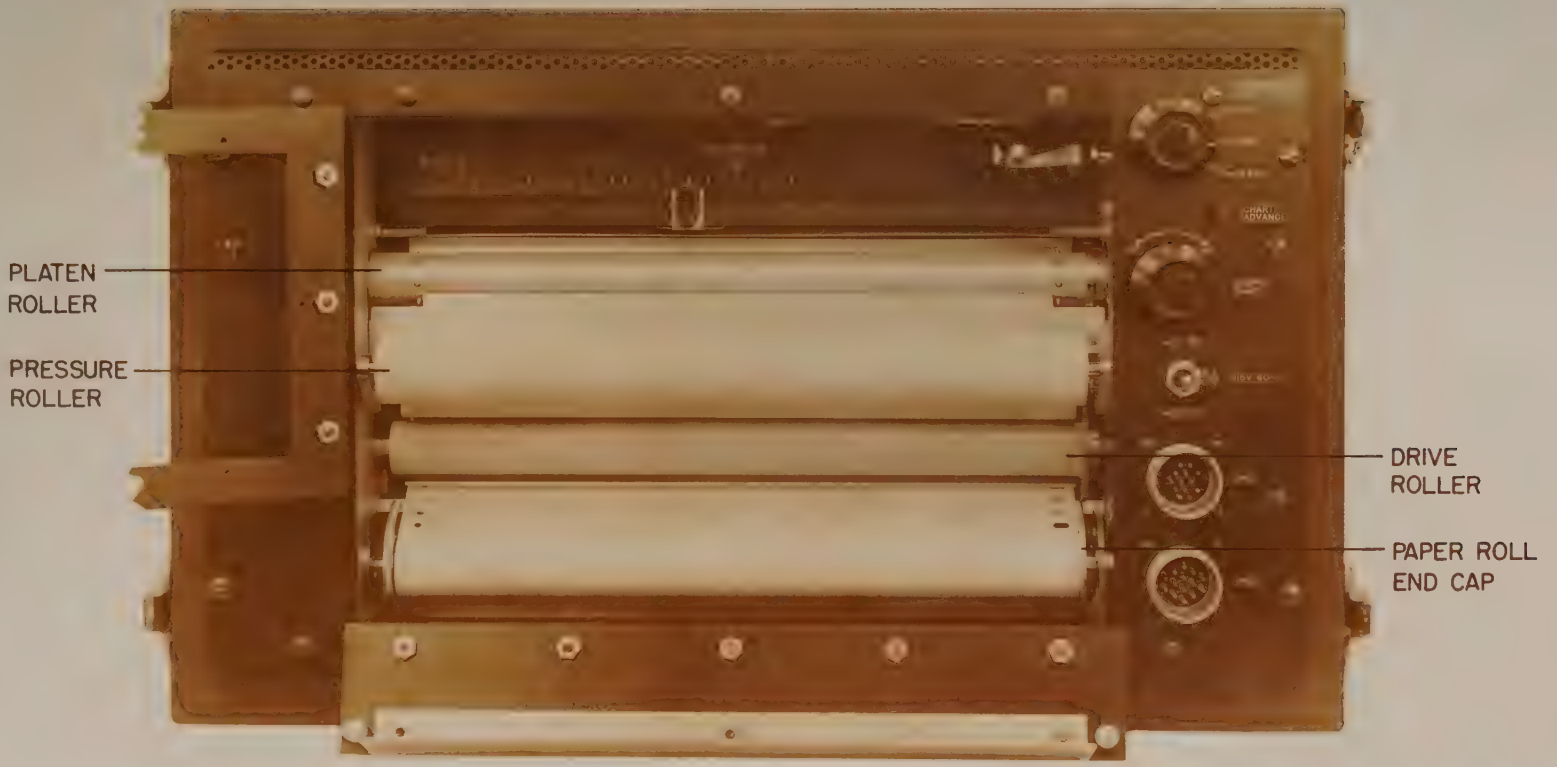

FIGURE 4-3. FRONT VIEW OF TYPE 373.4 RECTANGULAR COORDINATE RECORDER SHOWING PAPER ROLLERS

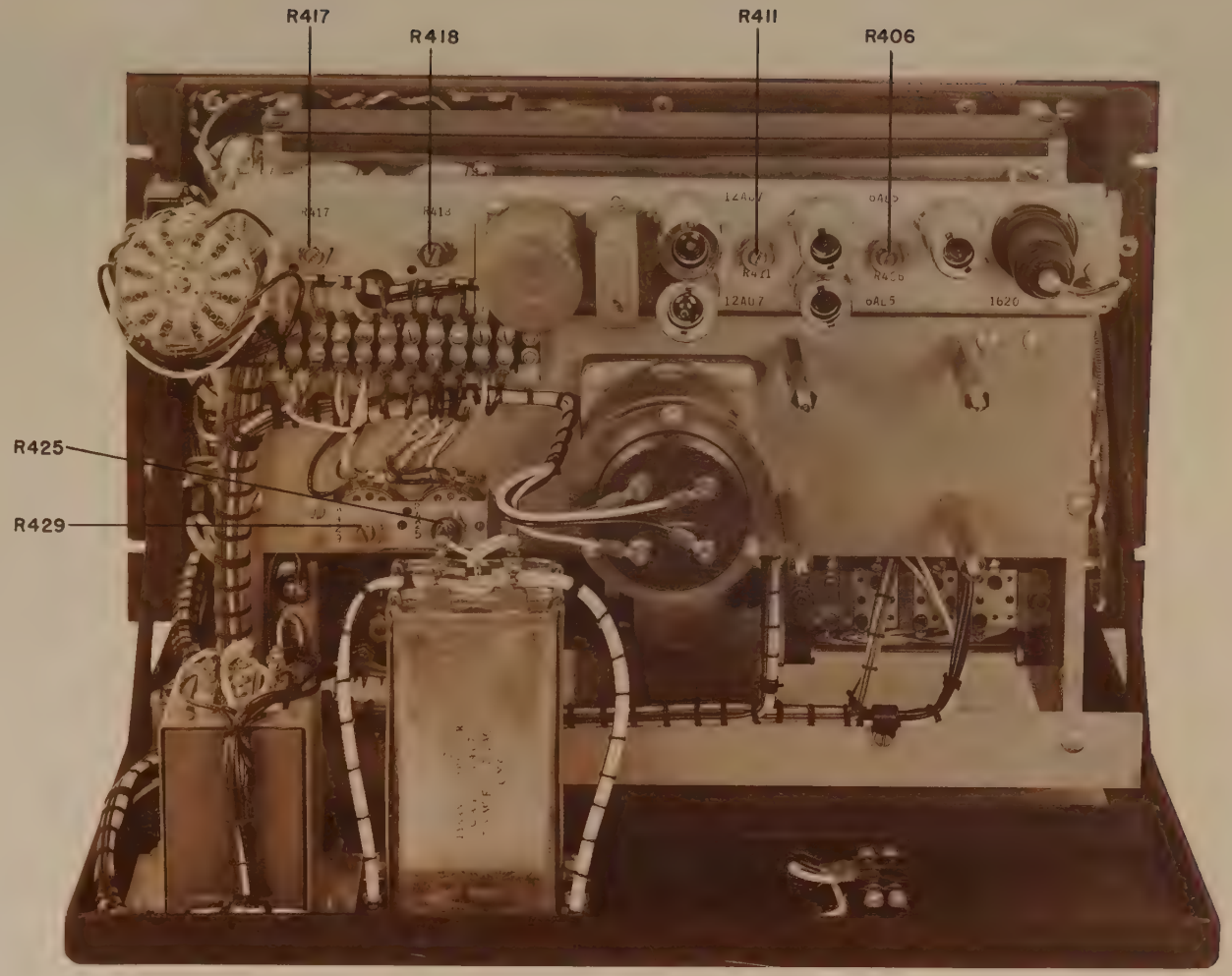

FIGURE 4-5. REAR VIEW OF TYPE 373.4 RECTANGULAR COORDINATE RECORDER SHOWING POSITION OF CONTROLS

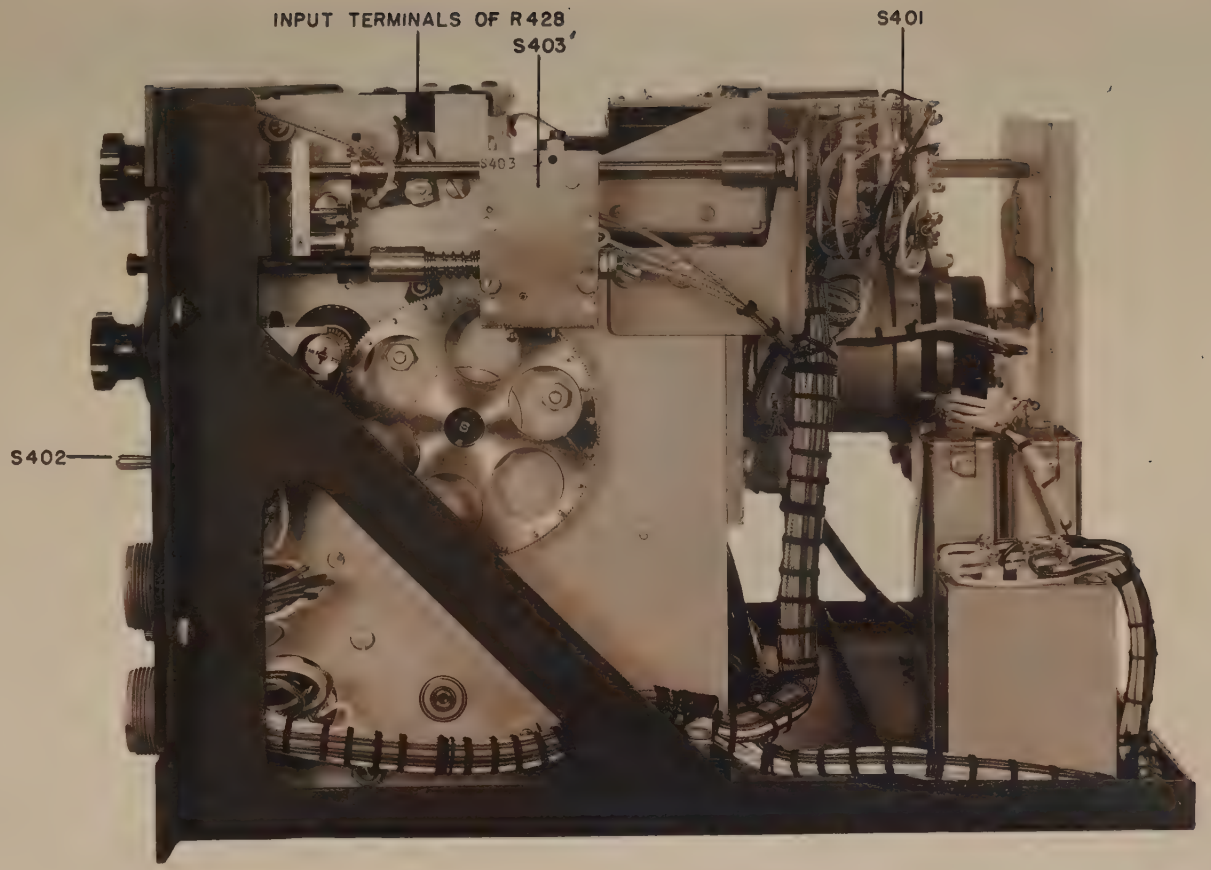

FIGURE 4-6. RIGHT SIDE OF TYPE 373.4 RECTANGULAR COORDINATE RECORDER SHOWING POSITION OF CONTROLS

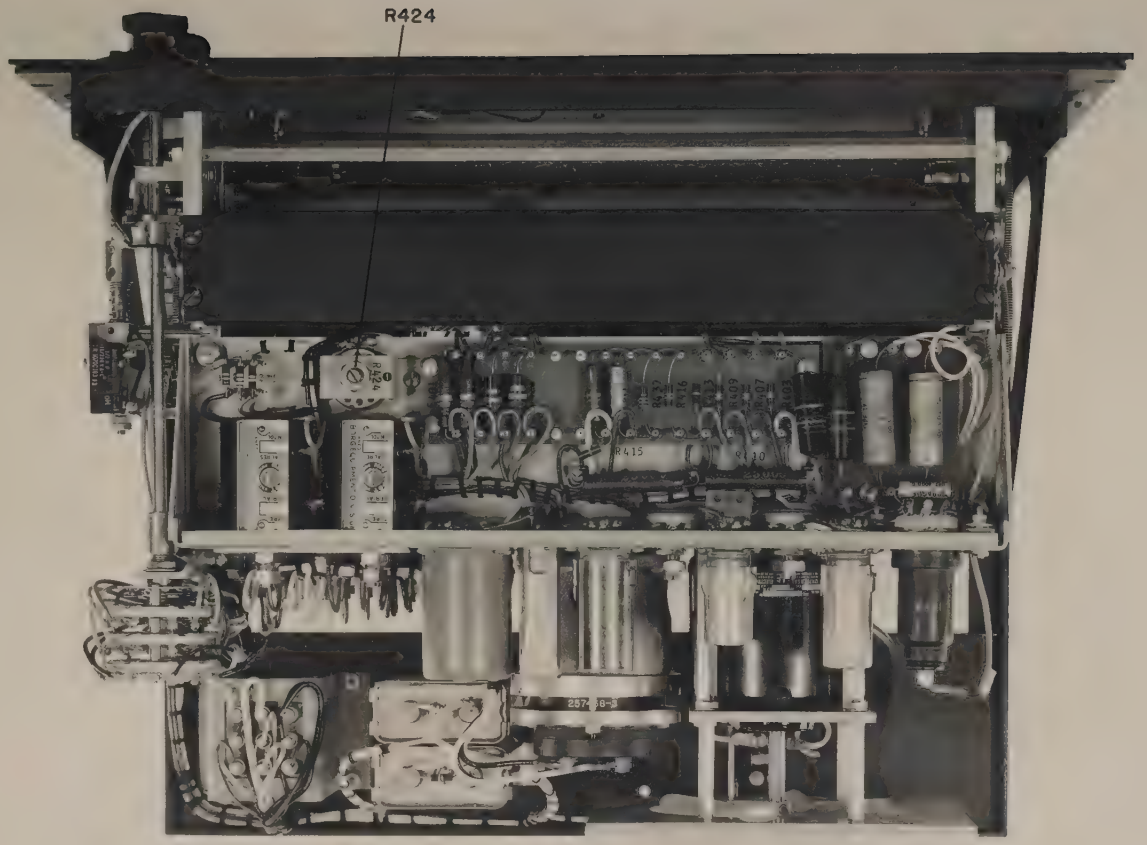

FIGURE 4-7. TOP VIEW OF TYPE 373.4 RECTANGULAR COORDINATE RECORDER SHOWING POSITION OF CONTROLS

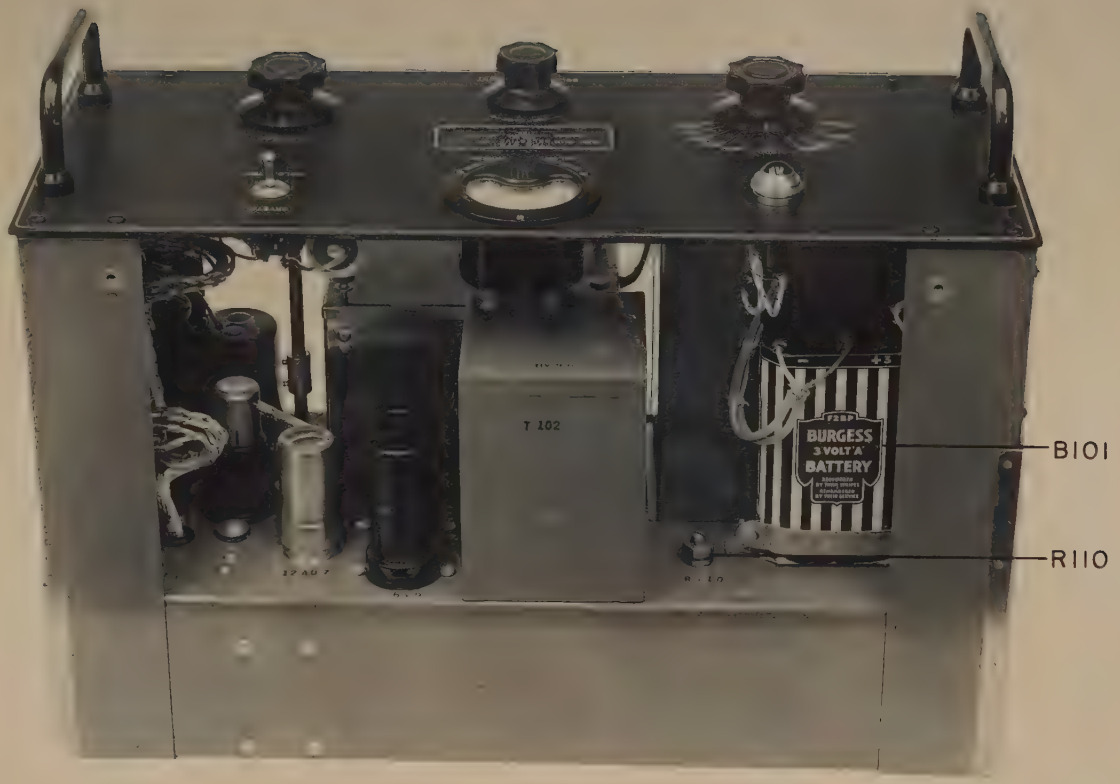

FIGURE 4-8. TYPE 373.1 SELECTIVE AMPLIFIER WITH DUST COVER REMOVED

SECTION 5

TABLE OF REPLACEABLE PARTS

SELECTIVE AMPLIFIER

Reference Symbol	Description	Manufacturer	Designation
B101	Battery, 3.0 v	BGS	F2BP
C101	Capacitor, 50 µf, 50 v	CLD	BR505
C102	Capacitor, 0.5 µf, 600 v	TBD	OM-650
C103	Capacitor, 0.022 µf, 400 v	SPR	88P22304
C104	Capacitor, 2.0 µf, 600 v	CLD	DYR6200G
C105	Capacitor, same as C104		
C106	Capacitor, same as C101		
C107 through C110	Capacitor, 0.047 µf, 400 v	SPR	88P47304
C111	Capacitor, 0.01 µf, 300 v	CLD	1W3S1
C112	Capacitor, same as C111		
C113	Capacitor, 482 µµf/Sect., 4 Sect. Var.	OAK	Model 60, AIL-373-10-A20
C114 through C116	Capacitor, 10-110 µµf trimmer	SPR	A08-002
C117	Capacitor, 100 µµf, silver mica	ERC	370FA
C118	Capacitor, same as C117		
C119	Capacitor, 250 µµf, silver mica	ERC	370FA
C120	Capacitor, 50 µµf, silver mica	ERC	370FA
C121	Capacitor, 30 µµf, silver mica	EMM	CM20-300
C122	Capacitor, 82 µµf, silver mica	EMM	CM20-820
C123	Capacitor, 1000 µf, 6 v	AEV	PRS-6
F101	Fuse, 3 amp	BUS	4AG-3A
I101	Pilot light bulb	SLE	S-44

TABLE OF REPLACEABLE PARTS
SELECTIVE AMPLIFIER

Reference Symbol	Description	Manufacturer	Designation
J101	Receptacle	AMP	83-1R
J102	Receptacle	AMP	AN3102-20-7P
J103	Receptacle	AMP	AN3102-20-11
J104	Receptacle	AMP	AN3102-20-16P
L101	Reactor, filter	UNT	D7622 Hermetically Sealed
M101	Meter, 0-15 ma, dc	WX	NX-33
R101	Resistor, 200 ohms, stepped	Tech Lab	Model 600, AIL 373-10-A23
R102	Resistor, 500 k, wirewound, ±1%	IRC	WW4
R103	Resistor, same as R102		
R104	Resistor, 250 k, wirewound, ±1%	IRC	WW4
R105	Resistor, 1.2 meg, 1/2 w, ±10%	IRC	EB1251
R106	Resistor, same as R102		
R107	Resistor, 3 k, 1 w, wirewound, ±10%	IRC	BW1
R108	Resistor, 1.0 meg, 1/2 w, ±10%	AB	EB1051
R109	Resistor, 220 k, 1/2 w, ±10%	AB	EB2241
R110	Potentiometer, 1 k, 2 w, ±10%	AB	JLU1021
R111	Potentiometer, 1 meg, 2 w, ±20%	AB	JA1052
R112	Resistor, 100 k, 1/2 w, ±10%	AB	EB1041
R113	Resistor, 5.6 k, 1/2 w, ±10%	AB	EB5621
R114	Resistor, 470 k, 1/2 w, ±10%	AB	EB4741
R115	Resistor, same as R112		
R116	Resistor, 3.3 k, 1/2 w, ±10%	AB	EB3321
R117	Resistor, 20 k, 1 w, ±5%	AB	GB2035
R118	Resistor, 1.5 k, 1/2 w, ±10%	AB	EB1521
R119	Resistor, 18 k, 1 w, ±10%	AB	GB1831

TABLE OF REPLACEABLE PARTS

SELECTIVE AMPLIFIER

Reference Symbol	Description	Manufacturer	Designation
R120 through R122	Resistor, same as R114		
R123	Resistor, 220 ohms, 2 w, ±10%	AB	HB2211
R124	Resistor, 680 k, 1/2 w, ±10%	AB	EB6841
S101	Switch, dpdt	BDR	SW-1120
T101	Transformer, input	TRM	HG-1
T102	Transformer, output	AUO	A7342 AIL-90-6-A112
V101	Tube	RCA	1620
V102	Tube	RCA	1620
V103	Tube	RCA	12AU7
V104	Tube	RCA	6V6
V105	Tube	RCA	6V6
XI101	Pilot light assembly	DMC	#80 Red

TABLE OF REPLACEABLE PARTS

SERVO AMPLIFIER

Reference Symbol	Description	Manufacturer	Designation
C201	Capacitor, 150 μμf, 300 v	CLD	5W5T15
C202	Capacitor, same as C201		
C203	Capacitor, 0.1 μf, 600 v	CLD	YAB6010G
C204	Capacitor, same as C203		
C205	Capacitor, 0.25 μf, 600 v	CLD	YAB6025G
C206	Capacitor, 0.5 μf, 600 v	CLD	DYR6050G
C207	Capacitor, 4.0 μf, 600 v	CLD	TLAD6040G
C208	Capacitor, 8.0 μf, 600 v	CLD	TJU6080G
F201	Fuse, 2 amp	BUS	4AG-2A
I201	Pilot light bulb	SLE	S-44
J201	Receptacle	AMP	AN3102-20-25P
L201	Reactor, filter	AUO	A6546/AIL 90-7-A15
L202	Reactor, same as L201		
R201	Potentiometer, 50 k, 2 w, ±10%	AB	JLU5031
R202 through R204	Not used		
R205	Resistor, 270 k, 1/2 w, ±5%	AB	EB2745
R206	Resistor, 1.0 meg, 1/2 w, ±5%	AB	EB1055
R207	Resistor, 100 k, 1/2 w, ±5%	AB	EB1045
R208	Resistor, 510 ohms, 1/2 w, ±5%	AB	EB5115
R209	Resistor, 3.9 k, 1/2 w, ±10%	AB	EB3921
R210	Resistor, 220 k, 1/2 w, ±10%	AB	EB2241
R211	Resistor, 470 k, 1/2 w, ±10%	AB	EB4741
R212	Resistor, same as R209		
R213	Resistor, 100 k, 1/2 w, ±10%	AB	EB1041

TABLE OF REPLACEABLE PARTS

SERVO AMPLIFIER

Reference Symbol	Description	Manufacturer	Designation
R214	Resistor, same as R211		
R215	Resistor, 1.5 k, 1/2 w, ±10%	AB	EB1521
R216	Resistor, 22 k, 1 w, ±5%	AB	GB2235
R217	Resistor, 390 k, 1/2 w, ±10%	AB	EB3941
R218	Resistor, same as R217		
R219	Resistor, same as R211		
R220	Resistor, same as R211		
R221	Resistor, 250 ohms, 5 w,	SPR	Koolohm NIT
R222	Resistor, 18 k, 2 w, ±10%	AB	HB1831
R223	Resistor, 15 k, 10 w, ±10%	OM	Brown Devil
R224	Resistor, 50 k, 20 w	OM	Brown Devil
S201	Switch, dpst	BDR	SW-1119
T201	Transformer, power	AUO	A5976/AIL 90-6-A22
T202	Transformer, output	AUO	A7343/AIL 90-6-A99
T203	Transformer, input	AUO	A7344/AIL 90-6-A109
V201	Tube	RCA	12AU7
V202	Tube	RCA	6C4
V203	Tube	RCA	6L6
V204	Tube	RCA	6L6
V205	Tube	RCA	0A2
V206	Tube	RCA	5R4-GY
XI201	Pilot light assembly	DMC	#80 Red

TABLE OF REPLACEABLE PARTS

POWER SUPPLY

Reference Symbol	Description	Manufacturer	Designation
C301	Capacitor, 4.0 µf, 600 v	CLD	TLAD6040G
C302	Capacitor, same as C301		
C303	Capacitor, 2.0 µf, 600 v	CLD	DYR-6200G
C304	Capacitor, 0.1 µf, 600 v	CLD	DY-6010G
C305	Capacitor, same as C303		
E302	Cover, receptacle	AMP	9760-14
F301	Fuse, 2 amp	BUS	4AG-2A
F302	Fuse, 3 amp	BUS	4AG-3A
F303	Fuse, same as F302		
I301	Pilot light bulb	SLE	S-44
I302	Pilot light bulb	GE	NE-51
J301	Receptacle	AMP	AN3102-20-16S
J302	Receptacle	AMP	AN3102-20-1S
J303	Receptacle	AMP	AN3102-20-25S
J304	Receptacle, same as J303		
J305	Receptacle	AMP	AN3102-14S-2P
J306	Receptacle, same as J305		
L301	Reactor, filter	AUO	A6546/AIL-90-7-A15
L302	Reactor, same as L301		
R301	Resistor, 50 k, 20 w	OM	Brown Devil
R302	Resistor, 12 k, 10 w	OM	Brown Devil
R303	Resistor, 12 k, 2 w, ±5%	AB	HB1235
R304	Resistor, 470 k, 1/2 w, ±5%	AB	EB4745
R305	Resistor, 15 k, 2 w, ±5%	AB	HB1535
R306	Resistor, same as R304		

TABLE OF REPLACEABLE PARTS

POWER SUPPLY

Reference Symbol	Description	Manufacturer	Designation
R307	Potentiometer, 10 k, 2 w, ±10%	AB	JLU1031
R308	Resistor, same as R303		
R309	Resistor, 1.0 meg, 1/2 w, ±10%	AB	EB1051
R310	Resistor, 68 k, 1 w, ±5%	AB	GB6835
R311	Resistor, 200 k, 1/2 w, ±10%	AB	EB2041
R312	Resistor, 47 ohms, 1/2 w, ±10%	AB	EB4701
S301	Switch, dpst	BDR	SW-1119
T301	Transformer, power	AUO	A5976/AIL-90-6-A27
V301	Tube	RCA	5R4-GY
V302	Tube	RCA	0A2
V303	Tube	RCA	6AS7
V304	Tube	RCA	12AX7
V305	Tube	RCA	5651
XI301	Pilot light assembly	DMC	#80 Red
XI302	Pilot light assembly	DMC	#80 Clear

TABLE OF REPLACEABLE PARTS

RECTANGULAR COORDINATE RECORDER

Reference Symbol	Description	Manufacturer	Designation
C401	Capacitor, 2.0 µf, 200 v	TBD	T-K
C402	Capacitor, 0.1 µf, 400 v	SPR	67P10404
C403	Capacitor, same as C401		
C404	Capacitor, same as C402		
C405	Capacitor, .01 µf, 300 v	SPR	65P10303
C406	Capacitor, .022 µf, 200 v	SPR	65P22302
C407	Capacitor, .25 µf, 600 v	TBD	OM-625
C408	Capacitor, 1.0 µf, 600 v	CLD	DYR6100
C409	Not used		
C410 through C412	Not used		
C413	Capacitor, 7.5 µf, 330 v ac	GE	21F4107-G102
C414	Capacitor, same as C413		
C415	Capacitor, .047 µf, 400 v	SPR	88P47304
C416	Capacitor, 25 µµf, 300 v	ERC	Ceramicon-Type 750 K
C417	Capacitor, same as C415		
CT401	Control Transformer	Ford	1HCT-MK.5, Mod. 3A
CT402	Control Transformer, same as CT401		
IG401	Induction Generator	KO	0945B-1600
IG402	Induction Generator, same as IG401		
IM401	Induction Motor	Ford	629799
IM402	Induction Motor, same as IM401		
IM403	Induction Motor	Transicoil	1900-Model 20 AIL Mod. 373-40-B75
IM404	Induction Motor	Universal	19WMB

TABLE OF REPLACEABLE PARTS

RECTANGULAR COORDINATE RECORDER

Reference Symbol	Description	Manufacturer	Designation
J401	Receptacle	AMP	AN3102-20-11P
J402	Receptacle	AMP	AN3102-20-1P
	Pen, Inking	Ullrich	Stylo #36
R401	Resistor, 100 k, 1/2 w, ±10%	AB	EB1041
R402	Not used		
R403	Resistor, 220 k, 1/2 w, ±10%	AB	EB2241
R404	Not used		
R405	Resistor, 2.7 k, 1/2 w, ±10%	AB	EB2721
R406	Potentiometer, 250 k, 2 w, ±20%	AB	JLU2542
R407	Resistor, same as R403		
R408	Resistor, 4.7 k, 1/2 w, ±10%	AB	EB4721
R409	Resistor, same as R401		
R410	Resistor, 25 k, 10 w	OM	Brown Devil
R411	Potentiometer, 1 k, 2 w, ±10%	AB	JLU1021
R412	Resistor, 1.0 meg, 1/2 w, ±10%	AB	EB1051
R413	Resistor, same as R412		
R414	Resistor, 1 k, 1/2 w, ±10%	AB	EB1021
R415	Resistor, same as R410		
R416	Resistor, same as R403		
R417	Potentiometer, 500 ohms, 10 turn	GBS	Micropot
R418	Potentiometer, same as R414		
R419	Resistor, 2250 ohms, 1 w, 5%	IRC	BW1
R420	Resistor, same as R419		
R421	Resistor, 56 kilohms, 2 w, 5%	AB	HB5635
R422	Resistor, same as R421		
R423	Resistor, same as R401		
R424	Potentiometer, 25 k, 2 w, ±10%	AB	JLU2531

TABLE OF REPLACEABLE PARTS

RECTANGULAR COORDINATE RECORDER

Reference Symbol	Description	Manufacturer	Designation
R425	Potentiometer, same as R424		
R426	Resistor, 9.1 k, 1/2 w, ±5%	AB	EB9125
R427	Resistor, 1.8 k, 1/2 w, ±5%	AB	EB1825
R428	Logarithmic attenuator, 340 ohms	AIL	373-40-C36
R429	Potentiometer, 100Ω, 2W, ±10%	AB	JLU-1011
R430	Resistor, 910Ω, ½W, ±5%	AB	EB-9115
R431 through R433			
R434	Resistor, 47 k, 1/2 w, ±5%	AB	EB4735
R435	Resistor, 39 k, 1/2 w, ±5%	AB	EB3935
R436	Resistor, same as R412		
R437	Resistor, 330 k, 1/2 w, ±5%	AB	EB3345
R438	Resistor, 560 k, 1/2 w, ±5%	AB	EB5645
R439	Resistor, 3.9 k, 1/2 w, ±10%	AB	EB3921
R440	Resistor, same as R401		
S401	Switch	OAK	DHC/AIL 90-10-A35
S402	Switch	CLH	7613-K2
S403	Switch	GE	CR1070-C103F3
T401	Transformer, output	UMT	C5689
T402	Transformer, filament and reference	AUO	A7345/AIL 90-6-A110
V401	Tube	RCA	1620
V402	Tube	RCA	6AU6
V403	Tube	RCA	6AL5
V404	Tube	RCA	6AL5
V405	Tube	RCA	12AU7
V406	Tube	RCA	12AU7

TABLE OF REPLACEABLE PARTS

INTERCONNECTING CABLES (TYPE 373 SYSTEM)

Reference Symbol	Description	Manufacturer	Designation
CC102 through CC104	Cable Clamp	AMP	AN3057-12
CC201A	Cable Clamp	AMP	AN3057-12
CC201B	Cable Clamp, same as CC201A		
CC301 through CC304	Cable Clamp	AMP	AN3057-12
CC305-6	Cable Clamp	AMP	AN3057-6
CC401	Cable Clamp	AMP	AN3057-12
CC402	Cable Clamp, same as CC401		
P101	Plug	WE	PL-259
P102	Plug	AMP	AN3106B-20-7S
P103	Plug	AMP	AN3106B-20-11P
P104	Plug	AMP	AN3106B-20-16S
P201A	Plug	AMP	AN3106B-20-25S
P201B	Plug, same as P201A		
P301	Plug	AMP	AN3106B-20-16P
P302	Plug	AMP	AN3106B-20-1P
P303	Plug	AMP	AN3106B-20-25P
P304	Plug, same as P303		
P305-6	Plug	AMP	AN3106B-14S-2S
P307	Plug, a-c line		
P401	Plug	AMP	AN3108B-20-11S
P402	Plug	AMP	AN3108B-20-1S

TABLE OF REPLACEABLE PARTS

INTERCONNECTING CABLES (TYPE 373A SYSTEM)

Reference Symbol	Description	Manufacturer	Designation
CC102 through CC104	Cable Clamp	AMP	AN3057-12
CC201A	Cable Clamp	AMP	AN3057-12
CC201B	Cable Clamp, same as CC201A		
CC301 through CC304	Cable Clamp	AMP	AN3057-12
CC305-6	Cable Clamp	AMP	AN3057-6
CC401	Cable Clamp	AMP	AN3057-12
CC402	Cable Clamp, same as CC401		
P101	Plug	WE	PL-259
P102	Plug	AMP	AN3108B-20-7S
P103	Plug	AMP	AN3108B-20-11P
P104	Plug	AMP	AN3108B-20-16S
P201A	Plug	AMP	AN3108B-20-25S
P201B	Plug, same as P201A		
P301	Plug	AMP	AN3108B-20-16P
P302	Plug	AMP	AN3108B-20-1P
P303	Plug	AMP	AN3108B-20-25P
P304	Plug, same as P303		
P305-6	Plug	AMP	AN3108B-14S-2S
P307	Plug, a-c line		
P401	Plug	AMP	AN3108B-20-11S
P402	Plug	AMP	AN3108B-20-1S

LIST OF MANUFACTURERS

AB	Allen-Bradley Co., Milwaukee, Wis.
AEV	Aerovox Corporation, New Bedford, Mass.
AIL	Airborne Instruments Laboratory, Inc., Mineola, N. Y.
AMP	American Phenolic Corporation, Chicago, Ill.
AUO	Audio Development Co., Minneapolis 7, Minn.
BDR	Bud Radio, Inc., Cleveland, Ohio
BGS	Burgess Battery Co., Freeport, Ill.
BUS	Bussmann Mfg. Co., St. Louis, Mo.
CLD	Cornell-Dubilier Electric Corp., Chicago 50, Ill.
CUT	Cutler-Hammer, Inc., Milwaukee, Wis.
DMC	Drake Manufacturing Co., Chicago 22, Ill.
EAD	Eastern Air Devices, Inc., Brooklyn, N. Y.
EMM	Electro Motive Mfg., Co., Inc., Willimantic, Conn.
ERC	Erie Resistor Corp., Erie, Pa.
Ford	Ford Instrument Co., Long Island City 1, N. Y.
GBS	Thomas B. Gibbs and Co., Delavan, Wis.
GE	General Electric Co., Schenectady, N. Y.
IRC	International Resistance Co., Philadelphia, Pa.
KO	Kollsman Instrument Division of the Square D Co., Elmhurst, N. Y.
OAK	Oak Mfg. Co., Chicago 10, Ill.
OM	Ohmite Mfg. Co., Chicago 44, Ill.
RCA	Radio Corporation of America, Camden, N. J.
SLE	Sylvania Electric Products, Inc., Emporium, Pa.
SLM	Solar Mfg. Corp., New York 17, N. Y.
SPR	Sprague Electric Co., North Adams, Mass.

TBD	Tobe Deutschmann Corp., Canton, Mass.
Tech Lab	Tech Laboratories, Jersey City, N. J.
Transicoil	Transicoil Corp., New York 13, N. Y.
TRM	Thermador Electrical Mfg., Co., Los Angeles 22, California
Ullrich	J. Ullrich and Co., New York, N. Y.
Universal	Universal Electric Co., Owosso, Mich.
UNT	United Transformer Corp., New York 13, N. Y.
WE	Western Electric Co., Kearny, N. J.
WX	Westinghouse Electric and Mfg., Co., Meter Div., Newark, N. J.

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